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ON THE VALIDITY OF PROGENY TESTS OF SIRES OBTAINED ON CULLED POPULATIONS OF DAUGHTERS

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Under the scheme for progeny testing of sires presented in a series of papers, by Munro and his associates (1, 3, 4, 5) it is stipulated as a working condition that the progeny flocks serving as test material must be maintained strictly unculled through the laying year.

Exception has been taken to this rule on the grounds that it is economically unsound practice to carry obviously worthless or pathological specimens through a full year. Furthermore there is the important theoretical consideration whether such low producing birds do properly belong in the distributions. If it is true that they, in many cases, do not adequately express the low values of the pertinent variate means should be found for their theoretically sound elimination.

The Canadian R.O.P. operates under rules that allow for extensive but uncontrolled culling. Jensen (2) expressed misgivings as to the full validity of progeny tests as long as such culling was allowed. It would therefore seem to be of some value to devise a scheme whereby progeny testing may be applied with confidence to culled progeny flocks.

Considering this problem it was assumed as a working hypothesis that culling is in the main performed for the purpose of eliminating poor producers. Culling, therefore, will delete some area of low values, smaller or larger as the case may be, under any given distribution curve. The remaining truncated portion of such a curve will consequently show a higher numerical value of the arithmetic mean and a smaller sampling error. The problem then is to show under what conditions the means and sampling errors exhibited by the culled populations may be utilized, either directly or indirectly, to express approximately the same relationship as would have existed between the same populations in case these had remained in the unculled state to the end of the laying year.

For this purpose we selected the three populations A, B, and C, consisting of 127, 127 and 97 birds respectively, the distribution curves of which are shown in Figure 1. From these distributions we arbitrarily culled various percentages of the birds, in every case involving only the lowest producers. The new means thus obtained were then compared to their respective original known means and to one another. It was thought that

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the most logical procedure would be to recalculate by Pearson's (6) technique the original mean values from the means of the variously truncated distributions. Table 1 shows the original means, the means of the truncated distributions and the original means as recalculated from the truncated data. In parentheses are shown the various means as percentages of the original unculled means.

TABLE 1.—VALUES OF MEANS AND STANDARD DEVIATIONS OF THE ORIGINAL DISTRIBUTIONS OF THE TRUNCATED DISTRIBUTIONS AND OF THE ORIGINAL MEANS AS RECALCULATED FROM THE TRUNCATED DATA

Culled	A	B	C
		Original Distributions	
0%	186.65 ± 49.99	170.24 ± 52.37	195.98 ± 40.21
		Truncated Distributions	
16.5%		(109.0) 185.57 ± 42.48	
17.5%			(107.2) 210.13 ± 25.07
25.0%	(111.2) 207.58 ± 37.31	(113.0) 192.42 ± 39.47	(109.7) 214.90 ± 22.81
32.3%	(114.2) 213.08 ± 34.90		
44.0%	(118.9) 221.97 ± 31.93	(121.8) 207.40 ± 34.32	(114.5) 224.44 ± 16.66
		Original Values recalculated from Truncated Data	
16.5%		(99.4) 169.29 ± 53.95	
17.5%			(105.4) 206.60 ± 28.20
25.0%	(103.6) 193.46 ± 47.38	(100.4) 170.93 ± 53.34	(109.2) 213.95 ± 23.84
32.3%	(100.6) 187.74 ± 50.02		
44.0%	(103.0) 192.18 ± 48.40	(95.5) 162.50 ± 56.25	(113.4) 222.22 ± 18.64

Numbers in parentheses denote the given means as percentage of original values.

It will be seen that the errors experienced in recalculation are fairly small for distributions A and B. For distribution C, however, the recalculated means are essentially of the same order as the means of the truncated distributions. The significance of this observation is that the Pearsonian technique for recalculations on normal curves is not very well applicable to distinctly non-normal distributions such as the one shown by our population C, and probably by the majority of egg laying curves.

In Table 2 are shown the percentage differences between the means of Table 1 when these means were expressed as percentages of the three observed means. This table very clearly demonstrates that the means of the truncated distributions retain the interrelationship of the original means to a higher degree than do the recalculated means. Also it is demonstrated that the errors of interrelationship become progressively smaller for diminishing culling percentage. Culling should therefore be kept as moderate as possible and probably should not exceed 15 to 25%.

TABLE 2.—DIFFERENCE BETWEEN MEANS WHEN THESE ARE EXPRESSED AS PER CENT OF OBSERVED MEANS

Culled	Between Means of Distribution	Values of Means recalculated from truncated data %	Observed Means of truncated data %
17%	B – C	5.86	1.67
25%	A – B	3.14	1.61
	A – C	5.26	1.36
	B – C	8.40	2.96
44%	A – B	8.56	2.41
	A – C	9.61	3.77
	B – C	17.14	6.18

The small significance of the disturbance of the interrelationship between the means of truncated distributions, when truncation is at proportionately equal ordinates is well shown in Table 3.

TABLE 3.—VALUES OF MEANS, STANDARD ERRORS AND DIFFERENCES BETWEEN MEANS IN ORIGINAL DISTRIBUTIONS AND THE SAME AT VARIOUS LEVELS OF TRUNCATION

	A	B	C
Original	186.65 ± 4.456	170.24 ± 4.674	195.98 ± 4.104
Differences	$\frac{x}{\sigma} = 2.54$; $p = 0.011$	$\frac{x}{\sigma} = 4.14$; $p = 0.000047$	
Culled 16.5%		185.57 ± 4.57	209.63 ± 2.83
Difference		$\frac{x}{\sigma} = 4.41$; $p = 0.000017$	
Culled 25%	207.58 ± 3.850	192.42 ± 4.069	214.90 ± 2.670
Differences	$\frac{x}{\sigma} = 2.71$; $p = 0.007$	$\frac{x}{\sigma} = 4.43$; $p = 0.000015$	
Culled 44%	221.97 ± 3.817	207.40 ± 4.111	224.44 ± 2.260
Differences	$\frac{x}{\sigma} = 2.60$; $p = 0.009$	$\frac{x}{\sigma} = 3.63$; $p = 0.00029$	
Culled below 162.5 eggs	32.3% 213.08 ± 3.786	44.0% 207.40 ± 4.111	17.5% 210.13 ± 2.559
Differences	$\frac{x}{\sigma} = 1.02$; $p = 0.308$	$\frac{x}{\sigma} = 0.45$; $p = 0.653$	

The p values of this table remain practically constant for the same relationship as long as culling is according to uniform percentage. However if culling is performed so as to truncate at one or another arbitrarily fixed ordinate, the balance between the means so obtained is entirely foreign to the original relationships. This latter situation is probably more nearly true of the one existing where uncontrolled culling is accepted.

An interesting point is brought out by a further analysis of distribution C. Normal curves were fitted to the original data as shown in Figure 2 and to the same truncated at the 25% level, that is at the 170 egg ordinate. X^2 for the former gives $p < 0.01$ and for the latter $p = 0.20$, the difference being mainly brought about by the elimination of the irregular low tail.

Such low tail formations are rather a common occurrence in egg production curves, and it is questionable whether they do actually belong in normal phenotypic distributions or whether they are composed largely of more or less pathologic specimens. It would therefore seem that culling 15 to 25% of a population would conveniently solve this problem. Moderate culling would then seem to be a benefit to exact progeny testing.

On the above premises we would therefore recommend that the lowest producers should be culled from all sires' progeny flocks entered in a progeny testing scheme. Such culling should be according to one uniform percentage which probably should not exceed 25%. In practice this would

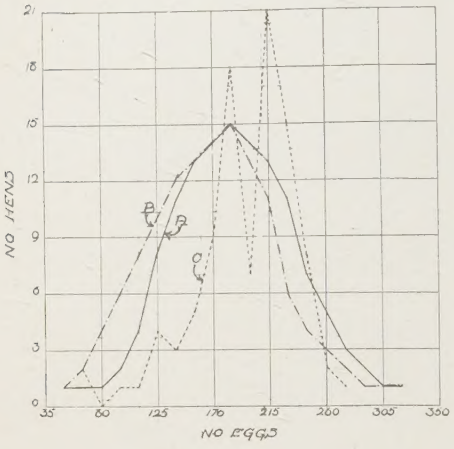

FIGURE 1

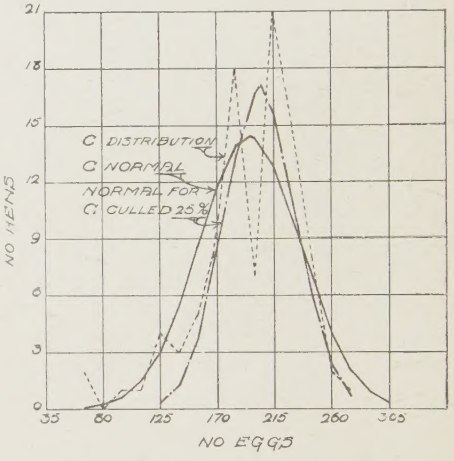

FIGURE 2

operate in such a manner that culling would be permissible throughout the year. Culling should be confined to the lowest producers only. Such practical culling will obviously not truncate the population according to any definite ordinate. To avoid the variability that might thereby be introduced no more than a maximum of 75% of the permissible culling should actually be performed while the test is in progress. The remaining portion of the permissible and obligatory culling, that is at least 25% thereof, should be "paper culled" after the completion of the test. Culling for egg size should not be permissible. In the first place, such culling will interfere with the proper evaluation of the genetic constitution for fecundity in the sire. In the second place, inheritance of egg size would thereby tend to be obscured. Culling for standard disqualifications should receive more attention than at present, but not while the test is in progress. For instance, if a character which disqualifies should be inherited in the simple ratio of 1 : 2 : 1 and therefore 25% of the individuals in a progeny flock will be discarded on sight, then obviously about 66% of the remaining birds will carry the factor and probably the whole flock should in most cases be eliminated before the test starts. By the end of the year the flocks would then compare on the basis of the means observed in the truncated distributions. In other respects the test should proceed as outlined by Munro and associates (*loc. cit.*).

It has been suggested that a male's breeding ability might more easily, and without loss of precision, be assessed on the basis of the per cent of his daughters whose annual production exceeded a common production standard. Hopkins, Munro and Bird (1) presented tables of necessary differences which reduce the chance of rating an ordinary male as truly superior to the standard to a basis of 1 in 20. Now a male the breeding worth of which is equal to the standard will, assuming normal distribution, have 50% of his daughters perform above the standard. However as the mean production of males' progeny moves above the standard in an endeavour to obtain the necessary difference which will designate that male as a truly superior male the percentage of daughters performing better than the standard will depend on the variance existing in the flock. Suppose the mean performance of a male's progeny flock to be located somewhere within the number of eggs constituting the necessary difference above the standard characteristic of that particular flock. Such a male will belong in the 95% of all males not rated as possessing truly superior breeding worth, and yet may quite possibly have 100% of his daughters perform better than the standard provided the variance attached to their mean performance is sufficiently low.

During the two years 1935–36 and 1936–37 the necessary differences have been determined for every sire's female progeny on the Dominion Experimental Farms. On analysis of this material it was found that the correlation between the percentage of daughters within progeny flocks that exceeded the standard of 200 eggs and the standard variations occurring in those same flocks amounted to $r = -0.85$. On the other hand the correlation between the percentage of daughters within progeny flocks that exceeded the standard and the extent to which the mean performance of each flock varied away from the full necessary difference was found to be $r = +0.02$.

It is therefore evident that determinations of the percentage of sires' daughters that exceed the standard does not furnish a reliable criterion for the segregation of superior breeding worth.

From the above mentioned progeny testing data it was found that 18 sires were rated as being possessed of truly superior breeding worth. Of all the daughters from these males 75% had annual productions in excess of the 200 egg standard. It may therefore tentatively be concluded that the chances for a male to qualify as a truly superior breeding sire will have been vitiated if on the average more than 25% of his daughters are disposed of by the combined effects of culling and mortality.

CONCLUSIONS

Observed means of culled populations may be compared directly because the errors introduced to the relationships between means by controlled culling are relatively small and unimportant. This statement holds as long as some definite and uniform percentage of the surviving birds in all populations being compared are culled.

Culling should be as moderate as possible and probably be kept within 15 to 25%.

Culling must have for its sole object the elimination of the low tails of egg production distributions. Introduction of any other consideration

will obscure and invalidate the proper estimation of the inherited egg production ability.

Distributions thus truncated probably more adequately express the true phenotypes of the populations than do the original undisturbed distributions with their quite frequently irregular tail formation.

Determinations of the percentage of sires' daughters that exceed the common production standard does not furnish a reliable criterion for the segregation of superior breeding worth.

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SOME OBSERVATIONS ON THE FUMIGATION OF APPLES WITH METHYL BROMIDE[1]

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Methyl bromide was first reported as an insecticide by Le Goupils (9) in 1932. More active investigations have been undertaken by entomologists during the last two years with this fumigant because of its toxicity to insects, non-explosive properties and facility of volatilization. Mackie and Carter (11 and 12) and Fisk and Shepard (4) have indicated in their publications the various products on which methyl bromide can be used.

Because of the low solubility in water of this fumigant there is some reason to believe that it may be used to destroy insects feeding internally in plant tissues, without damaging these tissues. Hence investigations were carried out to study the toxicity on apple feeding insects as well as the possible injury which might result to the apple.

EXPERIMENTAL PROCEDURE

Material Used and Method of Sampling

Previous to 1937 the main considerations were given to effect on the insect pests. The findings that the fumigation treatment necessary to kill the insects was harmful to the fruit under certain conditions necessitated a thorough investigation into fruit tolerance to the fumigation methods involved.

For this purpose McIntosh apples were used. They were grown on S. R. Jack's orchard at Châteauguay, P.Q. Twelve trees free from injury and disease and bearing a moderate crop were selected. All samples of fruit used in the experiment contained an equal number of apples from each tree.

The crop off these trees was picked at three different dates giving three maturities of fruit, one earlier, another at the same time, and another later than the recommended commercial picking maturity. One-half of each of these picks was stored at 39° F. and the other at 32° F., representing the extremes of ordinary commercial storage temperatures. Both of these groups were divided into four equal parts to be treated at four different times after picking, *i.e.*, T_0—treated immediately, T_2—two weeks, T_4—four weeks and T_6—six weeks after picking. Each of these last groups was made up of ten $\frac{1}{2}$-bushel hampers of approximately 60 apples in each. Each individual sample was exposed to 1 of 10 different fumigation treatments.

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Method of Fumigation and Handling

All samples of fruit, except when being fumigated, were stored at the Horticultural Division, Central Experimental Farm, Ottawa. Each group of apples fumigated at the same time was sent to the Dominion Fumigation Station, Montreal, where the necessary fumigation treatments were made as shown in Table 1.

Previous to the actual fumigation treatment, care was taken to see that the internal temperature of the apples was up to 60° F. so that the insects would be in a state of susceptibility to the fumigant. The fruit was then placed in a vacuum fumigation chamber of 30 cu. ft. capacity. This chamber was held at 80° F. by means of steam heating.

When the apples were placed in the vacuum chamber the required vacuum was created. The desired amount of fumigant was then allowed to flow into the evacuated chamber. The amount of gas was measured by increase in pressure by the usual method based on the simple gas law formula $PV = RnT$.

The fruit was exposed to the fumigant for 2 hours in the standard treatment, which period is 30 minutes in excess of the usual standard exposure time. At the end of this time a routine "air washing" was made with 2 successive vacua of 3" absolute pressure following the restoration of the pressure in the chamber to 27" absolute pressure. An electric fan in the chamber running 15 minutes on and 15 minutes off was used for gas circulation.

In previous experiments in 1936 the standard treatment with a proprietary fumigant containing approximately 7% methyl bromide and 93% carbon dioxide resulted in injury to the apples. In order to determine which phase of the technique was causing the damage the variations and components of the standard treatment were used as shown in Table 1.

The apples used for analytical work were those in the series receiving treatment No. 7 and kept at a storage temperature of 32° F.

Determination of Methyl Bromide Traces

The technique as finally adopted was based on a method designed for the determination of ethyl bromide in physiological material by F. L. Hahn (6). The sample under analysis was heated with aqueous vapor and air, the mixture being drawn by aspiration through a hot quartz tube. The organic bromide was decomposed and changed to hydrobromic acid. The hydrobromic acid was trapped in 2 gas washing bottles fitted with fritted glass bubblers and containing $N/2$ KOH.

Preparation of Sample

Five apples were chosen at random from the cold storage room, each apple being cut into three sections. The core sections were combined and analysed as a composite. The inner and outer cortex sections were similarly treated using suitable aliquots. To avoid loss of methyl bromide the apples were cut into moderately large pieces and quickly placed in tared flasks closed by rubber stoppers wrapped in tin foil and kept on ice. The aspiration was continued for one hour, when the gas washing bottles were washed into 200 m. volumetric flasks. The quantitative determination was carried out as described under "Total Bromine".

TABLE 1.—SYNOPSIS OF FUMIGATION TREATMENTS OF McINTOSH APPLES*

Treatment No.	Reference name	Gas used	Dose in lbs. per 1000 cubic feet	Initial vacuum (in inches absolute pressure)	Absolute pressure after introduction of dose	Post-dosage treatment	Absolute pressure during fumigation
1	Control	No treatment					
2	"Vacuum control"			3″		Maintained	3″
3	"CO_2 alone"	Carbon dioxide	107	0.7″	29.5″	Maintained	29.5″
4	"CO_2 and vacuum"	Carbon dioxide	32.5	3″	11.7″	Maintained	11.7″
5	Methyl bromide at atmosphere.	Methyl bromide	2.5	25″	25.3″	Dissipated with air	29.5″
6	Gas mixture at atmosphere.	Methyl bromide and carbon dioxide.	CH_3Br 2.45 CO_2 32.55	18″	27″	Dissipated with air	29.5″
7	Methyl bromide standard	Methyl bromide alone	2.5	3″	3.3″	Dissipated with air	27″
8	Gas mixture standard	Methyl bromide and carbon dioxide	CH_3Br 2.45 CO_2 32.55	3″	12″	Dissipated with air	27″
9	Methyl bromide and vacuum.	Methyl bromide	2.5	3″	3.3″	Maintained	3.3″
10	Gas mixture and vacuum	Methyl bromide and carbon dioxide	CH_3Br 2.45 CO_2 32.55	3″	12″	Maintained	12″

* Exposure period two hours. Vault temperature maintained at 80° F. Dosages and pressures originally applied in metric units.

Recovery of Methyl Bromide

From a small cylinder the methyl bromide was cautiously released through towers of N. KOH and conc. H_2SO_4 and allowed to condense in clean dry test tube buried in an ice-salt mixture. Using a chilled Mohr pipette a small amount of the condensate, which was clear and colorless, was measured into a chilled volumetric flask containing cold alcohol, 95% by volume. Suitable aliquots of this solution were used as in a determination and recoveries obtained as shown.

Added mgms.	*Recovered mgms.*	*Percentage*
1.386	1.272	91.7
1.386	1.314	94.7

Determination of Total Bromine

The technique for ashing the samples was essentially that used by Francis and Harvey (5), with modifications by Neufeld (14). The oxidation of bromides to bromate and subsequent iodometric titration was based on the method of Van der Meulen (16) and modified by Kolthoff and Yutzy (8).

According to Van der Meulen, bromides are quantitatively oxidised to bromates by $2\frac{1}{2}$ times the theoretical amount of hypochlorite in the presence of borate buffer and half saturation with NaCl.

$$3KClO + KBr \leftrightharpoons KBrO_3 + 3KCl$$

The reaction goes completely to the right if the oxidation is carried out at 85° C. and the excess hypochlorite is removed by hydrogen peroxide, which is in turn removed by boiling. Adding bromates to iodides in acid solution releases iodine, equivalent to 6 times the original amount of bromine.

$$HBrO_3 + 6HI \leftrightharpoons HBr + 3H_2O + 3I_2$$

D'Ans and Höfer (3) modified the technique using sodium dihydrogen phosphate in place of borate buffer, and sodium formate to remove excess hypochlorite.

Kolthoff and Yutzy found that for the determination of 25 ml. of 0.001 M bromide or less, the addition of sodium chloride was unnecessary.

TABLE 2.—RECOVERY OF ADDED POTASSIUM BROMIDE*

Added bromine, mgms.	Normality of thiosulphate	Thiosulphate used ML	"Blank" ML	Recovery MGM	Bromine percentage
0.2838	0.00978	2.42	0.26	0.2814	99.1
0.2838	0.00975	2.58 2.50	0.32	0.2883	101.6
0.2838	0.00975	2.40 2.44	0.27	0.2792	98.3
0.2270	0.00978	1.97	0.25	0.2241	98.7
0.2270	0.00978	1.99	0.25	0.2267	99.8
0.1700	0.00978	1.55	0.25	0.1693	99.6
0.9460	0.00510	14.50 14.50 14.44	0.72	0.9353	98.8
0.1810	0.004972	4.19 4.24 4.16	1.51	0.1782	98.4

* These values were determined on potassium bromide solutions.

Preparation of Sample

Five apples, chosen at random from the 32° F. storage room, were put through a meat grinder and thoroughly mixed. Portions were weighed out for moisture determinations.

Forty grams, weighed to the nearest decigram were ashed in nickel crucibles according to the reference above. The final ash extract was made to volume in 50 ml. flasks. Suitable aliquots were oxidised and the iodometric titrations completed. Blanks on the reagents were run daily. The thiosulphate solution was standardised daily also.

The recovery of bromine on adding potassium bromide to fumigated and control apples gave values of 98.7, 98.4% and 99.8 and 99.5%.

EXPERIMENTAL RESULTS

Toxicity to Insects Infesting Apples

Among insects liable to infest apples, Mackie and Carter (11) found, in 1937, that methyl bromide applied alone at the rate of 2.5 pounds per thousand cubic feet in dissipated vacuum treatment was completely toxic to larvae and pupae of the codling moth *Carpocapsa pomonella* Linn., in pears. Lindgren (10) also found, in 1936, that a proprietary fumigant containing methyl bromide and carbon dioxide in mixture was toxic to the larvae of the same insect buried in burlap sacks. These results were confirmed under Canadian conditions by McLaine and Monro (13). Mackie and Carter (11) also found the pure methyl bromide effective against the San José scale *Aspidiotus perniciosus* Comstock.

Fumigation of the Apple Maggot

Experiments conducted in 1936 against the apple maggot *Rhagoletis pomonella* Walsh infesting apples showed promise, and a more careful investigation was undertaken in 1937. An attempt was made to fumigate the apples in the stages of maturity in which they were likely to be shipped. In this condition the larvae are usually small, as the state of maturity of the apples influences the development of the maggots within the fruits. The maggots do not usually attain maturity and prepare to emerge from the apples until the fruit is overripe. Apples from Simcoe, Ontario, at different stages of maturity were forwarded to Montreal under the direction of Mr. W. A. Ross of the Entomological Laboratory, Vineland Station, Ontario.

For the most part these apples contained maggots from eggs which had been laid during the latter half of July, 1937. From what is known about the period of egg laying in the Simcoe orchards, and of the stage of development of the insect in both immature fruit and mature fruit fit to ship, it may be assumed that at the time of fumigation the apples contained a preponderance of small maggots and probably a few unhatched eggs. The apples were fumigated in the experimental vault of 30 cubic feet capacity as soon as possible after their arrival in Montreal, being subjected to the standard dissipated vacuum treatment for different periods of time as indicated in Table 3. The apples were then placed in metal cans which were examined periodically for emerged mature larvae, as these usually drop from the apples and congregate on the bottom of the cans. After the maggots ceased emerging, all the apples were cut open to find any further

TABLE 3.—TOXICITY OF METHYL BROMIDE TO LARVAE OF THE APPLE MAGGOT *Rhagoletis pomonella* WALSH*

Host variety	Origin	Date fumigated	No. of apples per treatment	Larval survival in apples					Emergence period of larvae from apples
				Treatment exposure in hours				Control	
				2	1½	1	½		
Immature Wealthy	Sent from Simcoe, Ont., Aug. 6, 1937.	Aug. 9	22	0	0	0	0	54	Aug. 31 – Sept. 4
Mature Wealthy	Sent from Simcoe, Ont., Aug. 20, 1937.	Aug. 25	20	0	0	0	0	7	Sept. 1 – Sept. 4
Fameuse	Sent from Simcoe, Ont., Aug. 23, 1937.	Aug. 25	20	0	0	0	2	51	Sept. 7 – Sept. 22
Fameuse	Sent from Simcoe, Ont., Aug. 30, 1937	Sept. 1	35	0	0	0	12	116	Sept. 9 – Sept. 29

* Methyl bromide applied at the rate of 2.5 pounds per 1000 cubic feet. Initial vacuum 3 inches of absolute mercurial pressure reduced by air after the introduction of the dose to 27 inches absolute pressure. Vault temperatures 80° F. to 82° F. Fruit temperatures 75° F. to 78° F.

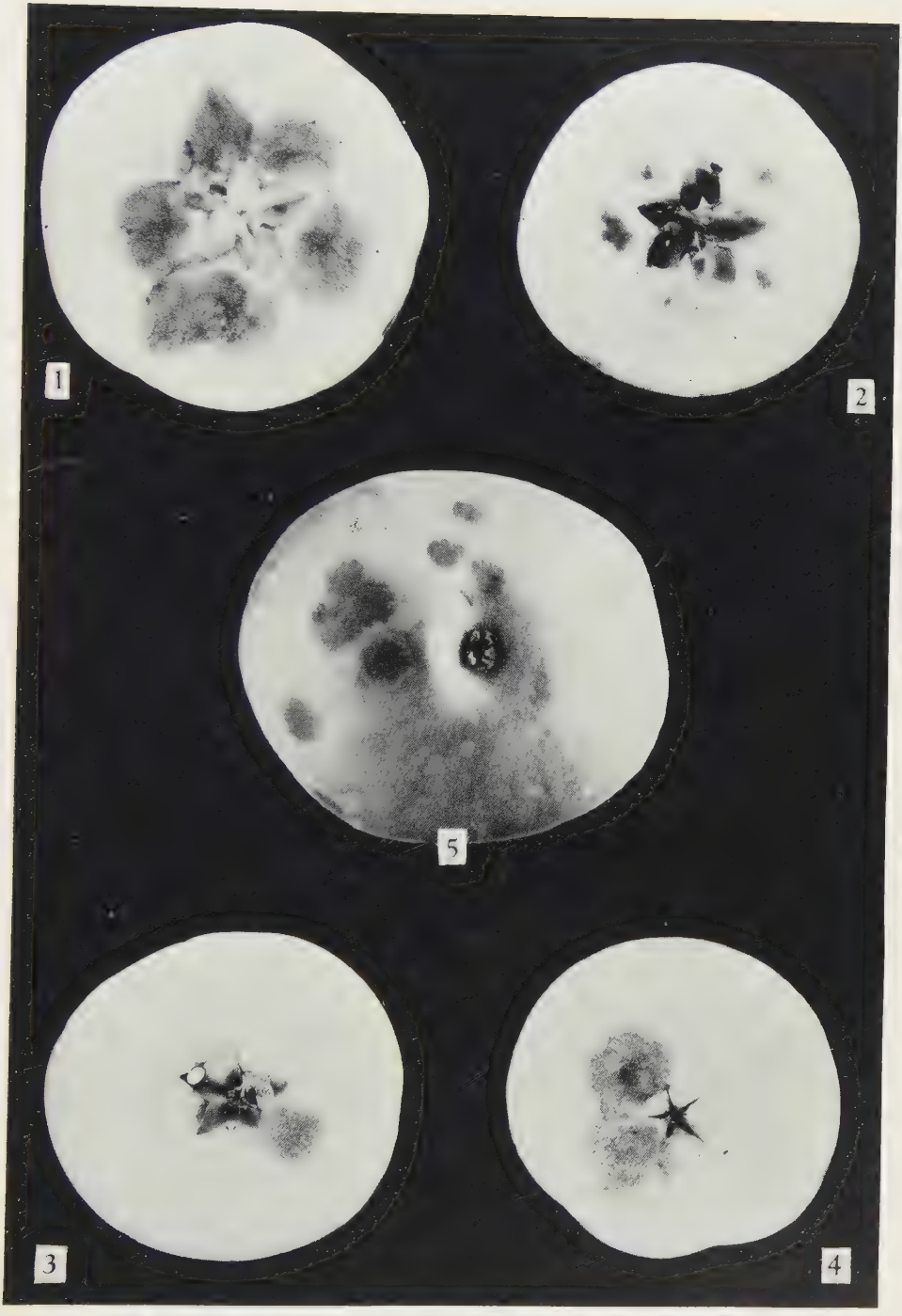

FIGURE 1. Methyl bromide injury in McIntosh apples. 1, 2, 3 and 4 illustrate internal injury and 5 external.

pupae which had formed inside. From the results summarised in Table 3 it would appear that the standard exposure period of 90 minutes is well within the limits of complete toxicity to the maggot in the stage of development found in apples at the time of shipping.

In addition to the toxicity of this treatment to any eggs of the insect which may have been present, other preliminary experiments have also indicated that it is effective against the eggs.

Cause of Injury to Apples

It has been shown that a method of fumigating apples, which has proven successful in destroying the infesting insects, has in several instances damaged the apple tissues. Figure 1 shows the external and internal injury found in apples after being exposed to methyl bromide fumigation treatment.

The data on which all fruit injury is based were obtained by examining the fruit between January 11th and 26th, 1938. At this time other storage disorders were just beginning to develop. Hence it was reasonable to assume that the point in storage had been reached at which fumigation injury had a maximum time to develop without being confused by other disorders. Half of each sample was examined on removal from storage. The remaining half was examined after one week's exposure to ripening conditions of 60° F. temperature and 90 to 95% relative humidity.

All injury has been classified into three types according to intensity—slight, moderate and severe. The percentage of apples affected with each type of injury was the basis for calculation. An injury index figure was then calculated by multiplying the percentage of slight by 1, moderate by 2 and severe injury by 3. Thus all calculations throughout this paper of injury index are based on a maximum of 300.

TABLE 4.—MEAN METHYL BROMIDE INJURY INDICES FOR THE VARIOUS FUMIGATION TREATMENTS*

Fumigation treatment	Internal Injury	External Injury
1. Control	0	0
2. Vacuum alone	0	0
3. 100% CO_2	0	0
4. CO_2 + vacuum	0	0
5. CH_3Br no vacuum	29.9	1.0
6. Ch_3Br gas mixture no vacuum	32.6	0
7. CH_3Br standard	27.7	1.3
8. CH_3Br gas mixture, standard	14.1	3.1
9. CH_3Br vacuum sustained	153.7	3.5
10. CH_3Br gas mixture vacuum sustained	15.8	2.7

* 1200 apples used for each calculation.

The mean injury index figures for all samples of fruit treated with each of the 10 treatments are shown in Table 4. From this table it is obvious that methyl bromide must be present in the fumigation treatment to cause the injury. It is interesting to note that the vacuum treatment and the CO_2 treatment in themselves result in no visible injury. One unfortunate feature is that most of the injury by far is internal rather than

external. Thus it is only by cutting the fruit that a true estimate of the injury can be made.

By further consulting Table 4 it is seen that considerable variation exists according to the manner in which the methyl bromide is applied. A very important consideration is that there is no advantage in not using the vacuum for fumigant penetration. The extent of injury resulting at atmospheric pressure is just as great as when the vacuum treatment is employed (compare treatments 5 and 7).

In all cases where the vacuum is employed there appears to be an appreciable reduction in methyl bromide injury by the use of CO_2 as compared to the same treatment without CO_2. The fact that the presence of CO_2 reduces the injury in the presence of the vacuum rather than without eliminates the possibility that the injury reduction was caused by more efficient control of the methyl bromide concentration.

Development of Injury after Removal from Store

Some storage disorders in fruit are not apparent immediately after removal from the store, but develop after exposure to ripening temperatures. This was not true in the case of the methyl bromide injury except in the case of No. 9 treatment (CH_3Br and sustained vacuum). The extent of injury in fruit exposed to this treatment, which incidentally was far more severe than necessary, increased to a large extent after a week's exposure to ripening conditions.

Table 5. Methyl bromide injury indices on removal and one week later for first pick of apples fumigated with No. 9 treatment

Temperature	Time elapse between picking and fumigation	On removal from store	One week of ripening
39° F.	0 weeks	148	300
	2 weeks	300	300
	4 weeks	40	136
	6 weeks	96	192
32° F.	0 weeks	178	264
	2 weeks	58	220
	4 weeks	0	18
	6 weeks	0	160

The fact that there should be more injury visible after one week's exposure to ripening conditions is not alarming. The fact, however, that in some cases no injury was apparent on removal and the injury index reached 160 in one week is hard to understand. It was only with the No. 9 treatment that this occurred.

The important feature is, however, that under any of the fumigation treatments which may be recommended, the amount of injury found on removal from store is a true criterion of the full extent of the damage.

The Effect of Storage Temperature

If the methyl bromide injury were a physiological one it was thought possible that the temperature of storage both previous to and after fumigation might have some influence on the extent of injury. It has been found

that McIntosh apples develop low temperature disorders at 32° F. which do not occur at 39° F. If temperature did influence the injury from a physiological standpoint it would be brought out by storing the apples at these two temperatures.

The results failed to reveal any significant difference in the extent of the injury. The mean methyl bromide injury index for treatment No. 7 at 39° F. was 83.0 and at 32° F., 87.0. For treatment No. 8 at 39° F. the mean was 40.5 and at 32° F., 44.0. Variables other than temperature showed such a great variation that these differences in temperature treatment were not significant. So it may be assumed that if temperature of storage does affect methyl bromide injury slightly, the cause is indirect rather than direct.

Effect of Maturity

It has been shown by Blackman (1) that apples pass through a definite metabolic drift both previous to and during ripening. Since this is true it is possible that apples may be more resistant to methyl bromide toxicity at one point in their ontogeny than at another.

If a variation in tolerance exists during the picking season it should be shown in a study of the injury found in the three maturities of apples represented in the experiment. The mean methyl bromide injury indices for all apples treated immediately after picking are as follows:

Maturity	Mean of all apples treated	Mean of apples treated immediately
1	29.8	77.4
2	14.8	23.1
3	24.4	60.3

These figures clearly illustrate that apples picked as in maturity 2 are much more resistant to methyl bromide injury than are the earlier or later pickings. Fortunately the second maturity represents the stage at which the apples should be picked for best storage results.

Effect of Delay between Picking and Fumigation

In the previous section it has been shown that the maturity of the fruit plays an important rôle in methyl bromide tolerance. However, it does not completely explain larger differences in the injury found in some samples.

If we assume that maturity 1 was at a stage of maturity designated by the letter A and maturity 2 and 3 by B and C, respectively, then maturity 1 would tend to proceed towards B, and maturity 2 toward C after picking. The injury then should decrease in maturity 1 after picking and increase in maturity 2 if maturity of the fruit were the sole consideration. Similarly maturity 3 might be expected to decrease in methyl bromide tolerance. This was not the case.

It was found that the third picking of fruit suffered much less if they were fumigated after a certain length of time in storage. If maturity were the only factor involved it is unreasonable that these fruits would behave in this way since the apples would tend to approach a more mature stage. It was found that all maturities behaved in this way, *viz.*, an increased tolerance to methyl bromide after picking.

The mean methyl bromide injury indices for all fruits treated with methyl bromide (3,600 fruit for each mean) at different time intervals was as follows:

Treated immediately	53.6
2 weeks after picking	20.3
4 weeks after picking	11.9
6 weeks after picking	5.3

It is obvious from these figures that the time elapse between picking and fumigation is a very important factor in avoiding methyl bromide injury.

Since these figures include treatments which were extremely severe it would be wise to consider the amount of injury involved with treatments of a standard nature. For this purpose the mean injury indices for treatments 7 and 8 fumigated at various intervals after picking are shown:

Treated immediately	23.3
2 weeks after picking	4.3
4 weeks after picking	3.5
6 weeks after picking	0.0

From these figures it can readily be seen that if the apples were allowed to remain in storage for two weeks, the amount of injury was reduced to a very slight amount. When a six-week period elapsed between picking and fumigation, the injury was completely avoided.

From the preceding data it has been shown that both the maturity and the time-elapse between picking and fumigation are important in decreasing the amount of fumigation injury. The next point to consider is the correlation between these two important factors. In Table 6 are shown the trends of injury both by maturity- and time-elapse between picking and fumigation.

TABLE 6.—EXTENT OF METHYL BROMIDE INJURY AS INFLUENCED BY MATURITY- AND TIME-ELAPSE BETWEEN PICKING AND FUMIGATION

Maturity	Time-elapse (weeks)	Methyl bromide injury index		
		All treatments	No. 7	No. 8
1	0	92.8	91.5	16.5
	2	30.9	12.0	16.0
	4	6.5	2.0	1.0
	6	11.2	0.0	0.0
2	0	26.9	2.5	0.5
	2	22.3	1.0	2.5
	4	12.3	6.5	0.0
	6	8.4	0.0	0.0
3	0	72.3	55.0	58.5
	2	19.3	3.5	3.0
	4	21.8	0.0	1.5
	6	3.8	0.0	0.0

From the figures in Table 6 it will be observed that if the apples are picked at the ideal stage of maturity (maturity 2) and are held in storage for two weeks, the extent of injury is reduced to insignificance by employing standard fumigation methods. Furthermore, by using these methods the extent of injury is completely reduced if a 6-week period is allowed to elapse regardless of maturity.

Relationship between Methyl Bromide and Injury to Apples:

From Table 7 it is obvious that there appears to exist very little correlation between the injury effects, as shown in the previous sections, and the amount of methyl bromide found by analysis. The illustration on Figure 1 shows that most of the injury is confined to the inner cortex and core area. Here again is found disagreement between analyses and the areas affected.

TABLE 7.—METHYL BROMIDE IN FUMIGATED APPLES

Treatment No. 7—Milligrams CH_3Br per kilo

Maturity of fruit	Time-elapse (weeks) between picking and fumigation	Core section	Inner cortex section	Outer cortex section	Whole apple	Condition of fruit
1*	0	11.0	14.0	19.0	18.0	5-internal injury.
1*	2	1.9	0.3	0.1	0.2	No injury.
1	4	1.5	0.3	0.2	0.2	1-internal; 1-skin lesion.
1	6	1.8	0.2	0.5	0.6	No injury.
2*	0	3.8	2.8	1.9	2.1	No injury.
2	2	4.4	0.6	0.7	0.8	No injury.
2	4	1.4	0.6	Nil	0.1	3-internal injury.
2	6	3.9	2.0	2.1	2.1	No injury.
3*	0	4.0	0.6	0.6	0.7	No injury.
3	2	Nil	0.3	<0.1	<0.1	No injury.
3	4	5.6	0.4	<0.1	0.3	1-internal injury.
3	6	10.5	0.9	1.9	2.2	No injury.

* Analysed by F. B. Johnston.
Untreated fruit gave no reaction for CH_3Br.

The only exception to these circumstances is found in the analyses of the first maturity sample fumigated immediately after picking. The high concentrations of methyl bromide in this case is difficult to explain.

Toxicity to Humans

The bromide residue in apples if sufficiently high would be toxic to human beings. Analyses were made to see if these residues were within a safe range of concentration in this respect.

Table 8 shows the results obtained on bromide residue determinations.

The method used would include any iodine present, but it is unlikely that this element is present in apples. Winton (17) gives a reference stating that apples do not contain iodine.

Neufeld (14) reports bromine in apples as 0.0003% on dry basis. Kitto (7) found less than one part per million on the wet basis. Damiens

and Blaignan (2) record the analysis of one sample of apples as containing traces of halogens.

The amounts of bromide residue found in fumigated apples do not appear to be large enough to be a factor in human nutrition. The increase in bromine content due to fumigation varied from 3 to 5 parts per million. If the bromine is fixed in the fruit tissue as inorganic sodium and potassium bromides, the amounts found are not physiologically significant, since it would require over 300 pounds of fumigated apples to furnish the average medicinal dose of these salts.

The Dow Chemical Company in the second edition of their booklet on methyl bromide state that "thorough analytical tests prove that the small amounts of bromine are present as inorganic bromides, such as potassium bromide, sodium bromide, etc."

TABLE 8.—BROMIDE RESIDUE IN FUMIGATED APPLES
Treatment No. 7—Bromine in mgms. per kilo

Maturity of fruit	Time elapse (weeks) between picking and fumigation	Total solids	As received	Dry basis	Increase in bromine due to fumigation		
					As received	Dry basis	Condition of fruit
1	0	13.31	6.1	45	5.2	39	5-severe injury.
1	2	11.85	4.5	38	3.7	32	1 slight injury.
1	4	12.40	4.1	33	3.3	27	No injury.
1	6	12.40	4.3	35	3.6	29	No injury.
2	0	13.33	4.5	34	3.7	28	No injury.
2	2	13.55	3.8	28	3.0	22	No injury.
2	4	13.18	4.9	37	4.1	31	No injury.
2	6	12.74	4.1	32	3.3	26	1—slight injury.
3	0	13.65	5.1	37	4.2	31	3—moderate injury.
3	2	13.44	4.6	34	3.7	28	No injury.
3	4	13.54	4.1	30	3.2	24	3—slight injury.
3	6	13.05	4.8	36	3.9	30	3—slight injury.
Controls		12.76	0.8	6	—	—	

Damiens and Blaignan (2) who have recorded the bromine content of a large number of fruits and vegetables report up to 26 milligrams of bromine per 100 grams dry matter (watermelons). Tomatoes were found to contain up to 5.3 milligrams of bromine per 100 grams of dry matter. These values are in excess of the amount found in the fumigated apples examined.

The amount of methyl bromide, as such found in the apples, is of a low order of magnitude, with the exception of 1st maturity sample treated immediately which appears to be abnormal. It is reasonable to assume that methyl bromide with a boiling point of 4.5° C. would soon escape from the fruit at higher temperatures.

DISCUSSION

From the experimental evidence it can be assumed that methyl bromide fumigation is practicable as applied for the destruction of insects infesting apples. The bromide residues resulting therefrom are well below

the danger point for human consumption. However, there exists a grave problem in that as applied the methyl bromide fumigant under certain conditions results in both external and internal injury to the apples.

The injury is caused by methyl bromide itself since CO_2 and the vacuum treatment or combinations of each failed to produce the injury recorded. The maturity of the apples as well as the delay between picking and fumigation had a profound influence on the resulting injury. The addition of carbon dioxide in the vacuum fumigation treatment lessened the extent of the injury. Furthermore, no co-relation exists between the amount of methyl bromide found in the tissues and the injury involved.

All these factors point to the fact that the injury caused by methyl bromide to the apple tissue is due to a physiological upset rather than mechanical destruction.

Respiration curves established from continuous 24-hourly CO_2 output records of apples picked at various stages show an upset condition in the apples' metabolism shortly after picking (15). This upset as shown by irregular and high rates is more severe in immature fruit.

If an apple is picked at the ideal stage the disturbance in CO_2 output at 55° F. lasts for about one week. After this a sharp decline is noted lasting for an additional two weeks. At this point a more uniform rate of CO_2 output exists. There may possibly be some relationship between these changes in trend and the tolerance to methyl bromide. If so it would seem that the apple is more able to resist the injury from the fumigant when a steady adjusted state of metabolism exists.

SUMMARY

The standard treatment of methyl bromide fumigation was found to be lethal to insects feeding internally in apples. The residue of bromide was found to so slight as to be harmless to human beings. Under certain conditions, however, methyl bromide under the various ways applied was found to cause both internal and external injury to the apples. If the apples are picked at the proper stage of maturity and are stored for six weeks at 32° F. or 39° F. and standard treatment used no injury results. It is concluded the damage is physiological rather than mechanical.

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CEREAL GROWING ON WEEDY LAND IN NORTH-EASTERN SASKATCHEWAN

EFFECT OF HEAVY SEEDING WITH THE USE OF FERTILIZER ON THE DEVELOPMENT OF WEEDS AND CROPS

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INTRODUCTION

In 1930, the Agricultural Service Department Committee, Chamber of Commerce of the United States, estimated that the loss from weeds in the United States was greater than that from plant diseases and insects together, and that it amounted yearly to approximately three billion dollars (1). One-third of this was directly due to the reduction in yield of crops caused by the presence of weeds.

No such analysis is available for this country, but there is no doubt that the loss from weeds here is enormous. For three succeeding years, a check was made of the loss of yield caused by weeds growing in the Saskatchewan Department of Agriculture plots. This was done by keeping a number of small representative areas free from all weed growth, and it was found that in 1931 weeds caused a loss of wheat of 30 per cent, in 1932 of 22.5 per cent, and in 1933 of 32.8 per cent. The degree of infestation of these fields was by no means extreme and the average loss from weeds in northeastern Saskatchewan may conservatively be put at 25 per cent of the crop value.

A great variety of weed species are found in grain crops of northeastern Saskatchewan. Some like the pigweeds (*Chenopodium album*, *Amaranthus retroflexus*, *Axyris amarantoides*), wild buckwheat (*Polygonum Convolvulus*), Russian thistle (*Salsola Kali*), etc., are only troublesome from time to time when the young crop is hindered in its development by frost, drought, disease or other causes. Perennial weeds like Canada thistle (*Cirsium arvense*), perennial sow thistle (*Sonchus arvensis*), couch grass (*Agropyron repens*), and others do much harm in grain crops, but their control is primarily a question of tillage (10). The same is true of biennial and winter annual weeds.

Among the annual weeds most troublesome in grain crops of northeastern Saskatchewan are wild mustard (*Brassica arvensis*) and allied species, wild oats (*Avena fatua*) and stinkweed (*Thlaspi arvense*). These have a very aggressive root system, and are able to thrive when other weeds are smothered by the crops. They ripen early, are very prolific, and shatter most of their seeds on the soil. Furthermore, the seeds show considerable dormancy and are able to remain in the soil for years without germinating. In 1931, a field of Garnet wheat in northeastern Saskatchewan, sown at the rate of one bushel per acre, without fertilizer, yielded eleven bushels of wheat and nineteen and a half bushels of stinkweed seed per acre. In the plots, under less severe conditions of weed infestation, weeds produced an average of over one thousand seeds per square foot, when crops were sown light and without phosphate fertilizer.

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This shattering of weed seeds makes it very difficult under ordinary conditions to clean up weedy fields, and it was primarily to curb the reinfestation of fields from that source that the experiments described in this paper were undertaken. For a few years much work was done with chemical spray for the control of weeds in grain crops, and the method was found effective and economical in many cases (8, 9). The fact, however, that the method was limited in its use to but a few weed species, and difficulties encountered in finding a sprayer well adapted to conditions in Saskatchewan, made it imperative to look for a method susceptible of wider application and not requiring expensive and elaborate farm equipment.

LITERATURE REVIEW

The method of drilling fertilizer with the seed instead of broadcasting it, was introduced into Canada from South Australia (20, 25) in 1928.

Rates-of-seeding experiments date further back. Bracken (2) reports on tests conducted at the University of Saskatchewan, and suggests rates of 1 to $1\frac{1}{2}$ bushels per acre for heavy soils. The lower rates are for stubble or any other condition when the reserve moisture is low, or when the seed is small; the heavier rates are to be used when moisture is plentiful or the seed above normal size, or when damage from late summer frosts is feared. Tinline (22) was in agreement with Bracken for conditions prevailing at Scott, but his report points out that thin seeding permitted a stronger growth of weeds, and that if one or two moist seasons had intervened, the average yield would have been in favour of the heavier rates of seeding. More recent tests at Scott by Matthews (17), and at Swift Current by Taggart (21), are also in favour of light seeding. Saskatoon, Scott and Swift Current are located outside the area where the more troublesome weeds are found in quantity (14) and conditions there are usually much more arid than in the park or in the wooded areas of the province. Few data on rates of seeding were available for non-prairie conditions. Munro (15) shows that at Rosthern, an average rate of seeding of $1\frac{3}{4}$ bushels of wheat per acre was best. Heavy seeding also gave best results on summerfallow at Brandon, according to tests reported by McKillican (16). Under controlled conditions, Clemens (26) found that straw, heads, leaf area and stooling decreased as the degree of competition between crop plants increased, but heavier yields of grain were still secured with twice normal seeding than with normal or half-normal seeding. Fairfield in Australia (5) found that the yield of grain increased as the plant population grew larger, but that evenness of seeding did not affect the yield.

A search of the literature revealed no rates-of-seeding experiments conducted prior to 1932 to determine the relation which might exist between various amounts of seed sown, and the development of weeds. Since that time, rates-of-seeding experiments with and without fertilizer have been undertaken at several experimental stations in Saskatchewan, and data are presented by Hopkins (12) for conditions prevailing at the Dominion Experimental Sub-station, Regina. Heavy seeding for weed control is now recommended by the Saskatchewan Committee on Weed Control (10).

Two interesting tests should also be mentioned, because the conditions there approach most closely those which are experienced in weedy fields. At Indian Head (16) wheat was sown at rates ranging from $\frac{1}{4}$ bushel per

acre to 2 bushels, in combination with 28 pounds of flax in one series, and with 42 pounds of flax in the other series. In both series it was found that as the rate of seeding wheat increased, the yield of wheat increased as well, but the yield of flax decreased. A 4-year test at Brandon (23) showed the same results.

MATERIAL AND METHODS

Location of Tests

All the experiments referred to in this paper were conducted in northeastern Saskatchewan, where soil and climatic conditions are probably more favourable than in any other parts of the province for the development of certain noxious weeds. This is one of the reasons why the area was selected. Another reason is that there was, at the time the experiments were started, no experimental station within that area.

The weed control method outlined in this paper originated from observations made in 1930 and in 1931 in the Watson area, and it is there that the first tests with rates of seeding were conducted (1932 and 1933). During 1934 and 1935, the plots were located at Melfort, at the desire of the Melfort Agricultural Society, but when the Dominion Department of Agriculture established an experimental station there, these tests were again conducted in the Watson district. For four years, the experiments were duplicated on the margin of the park area at Lockwood. In 1937, the work was extended and simple tests with wheat, oats and barley, sown light and heavy, with and without fertilizer, were carried out over a wide area.

The soil in the Watson area is described in the Saskatchewan Soil Survey as Yorkton Loam (13). The surface soil is very dark gray to grayish black in colour, and of soft small cloddy structure, and usually contains much lime. The subsoil is light gray, almost structureless, and very high in lime. The lower subsoil contains soluble salts in addition to lime.

At Melfort, the soil is medium to medium heavy, undulating, with good drainage. The surface soil consists of a deep black granular layer with a high content of organic matter. The upper subsoil is dark gray brown. The lower subsoil is grayish in colour, very high in lime, slightly cloddy in structure, grading into a dark gray heavy clay.

At Lockwood, the soil is a fine sandy loam of the Weyburn series. It is inferior from the standpoint of grain growing, and damage from soil drifting is frequent.

Perennial weeds, perennial sow thistle and couch grass especially, are quite troublesome in northeastern Saskatchewan, but their control is primarily a question of tillage. The most persistent annual weeds are wild oats (*Avena fatua*), stinkweed (*Thlaspi arvense*), and in places wild mustard (*Brassica arvensis*).

Until 1934 the rates-of-seeding and fertilizer tests were conducted with wheat only. Since then oats and barley of the type recommended for that area have been included in the experiments.

Experimental Technique

The selection of land suitable for weed control experiments in growing crops is a difficult task. To be very satisfactory for the purpose, a field must be level and representative of the district. There must also be

uniformity of soil and of degree and kind of weed infestation. Uniformity of soil is much easier to find than uniformity of weed infestation, and a satisfactory combination with regard to all variable factors is very seldom obtained.

To assure greater uniformity of the weed factor in the plots, it has been suggested that clean fields be selected and the weeds be sown. Unfortunately this is not practical for several reasons. First, the Department of Agriculture does not own the land on which the experiments are conducted, and very few farmers would consent to have clean fields sown to bad weeds. Second, weeds do not germinate uniformly like cereals. Probably very few seeds would germinate with the crop or the infestation would be patchy. Finally, unless a way was found to prevent the shattering of weed seeds on the plots before harvest, the land would soon become useless for experimental purposes, as reinfestation in plots sown light without fertilizer is usually several times greater than in plots sown heavy and with fertilizer.

Since a desirable uniformity was so difficult to obtain under field conditions, great care was taken to obtain reliable data, and a special method was followed during the first three years. This method was described in a previous paper (9) and consists briefly in seeding every other plot to a check, in securing yield data for each plot from three large representative samples instead of from the whole plot, and in pairing each sample with those from the checks on either side. As the experiments progressed and the evidence in favour of heavy seeding with the use of fertilizer accumulated, less check plots were believed necessary. From 1934 to 1937, all key plots were laid out in randomized blocks, with plots in triplicate, but data are still secured from representative samples in the plots. Yields and other information are obtained in each case from the average of three samples for each of three plots, or nine samples in all. The only departure from this system was in 1937, when apart from randomized blocks at Muenster, Lockwood and Yorkton, a series of minor tests was conducted for demonstration purposes. Each of these demonstrations consisted of 12 plots, 4 of wheat, 4 of oats and 4 of barley, without replication. Plots were long and narrow, one-half acre in size and samples were taken in pairs at the rate of 6 per plot.

RESULTS

Data are presented to show the effect of heavy seeding of cereals with the use of fertilizer on the development of weeds and crops. The data are presented under three sections:

A. Effect of fertilizer alone.
B. Effect of heavy seeding alone.
C. Effect of heavy seeding with the use of fertilizer.

A. Effect of Fertilizer Alone

The application of ammonium phosphate drilled in with the seed is very desirable under most conditions in the park and wooded soil areas of Saskatchewan. The fertilizer helps the crop along in early spring, especially when the soil is cool and soil bacteria are inactive. It plays an important part in checking losses from browning root rot (24), it increases

the earliness of crops, and is generally useful in controlling weeds. Table 1 shows its effect on the yield of wheat, oats and barley for conditions prevailing at Melfort in 1935.

TABLE 1.—EFFECT OF AMMONIUM PHOSPHATE DRILLED IN WITH THE SEED (25 LBS. PER ACRE) FOR CONDITIONS PREVAILING AT MELFORT IN 1935. CROP SOWN LIGHT

Crop	Date of seeding	Yield of grain, Bus. per acre		Days seeding to maturity		Percentage weed seeds to total crop	
		Not fert.	Fert.	Not fert.	Fert.	Not fert.	Fert.
Garnet	May 13	9.4	12.7	95	93	54.1	29.7
Marquis	May 13	15.5	19.3	106	104	21.9	14.6
Regal	May 14	19.7	30.6	92	90	44.9	18.5
Gopher	May 14	55.5	69.1	92	85	14.3	4.7
Regal	May 30	35.7	36.8	88	85	20.2	16.7
Gopher	May 30	42.5	53.3	84	79	15.3	10.5

When crops are sown light, aggressive weeds such as wild oats and wild mustard are not always kept under control, even though fertilizer is used, and this is especially true when seeding is done late. This fact is clearly shown in Table 2, data for Lockwood, 1932, and in Table 3, data for Englefeld, 1933. Note that in 3 out of 5 tests the amount of weed seeds produced in the crop increased with the use of fertilizer.

TABLE 2.—THE EFFECT OF AMMONIUM PHOSPHATE ON THE DEVELOPMENT OF WILD OATS IN PLOTS OF WHEAT SOWN AT DIFFERENT DATES

Date of seeding	Percentage dockage from wild oats at harvest		Percentage difference in dockage
	Crop not fertilized	Crop fertilized	
April 15	7.3	5.2	−28.8
May 1	7.3	6.7	− 8.2
May 15	4.9	6.5	32.6

TABLE 3.—THE EFFECT OF AMMONIUM PHOSPHATE ON THE DEVELOPMENT OF WILD MUSTARD IN WHEAT

	Seeding April 28			Seeding May 10		
	Not fert.	Fert.	Diff. in %	Not Fert.	Fert.	Diff. in %
Average height of plants (inches)	18¼	23	+25.7	17¼	20¾	+20.3
Average number of pods per plant	32.8	50.5	+53.9	19.5	35.2	+80.5
Average yield of mustard seed per sample (grams)	11.1	12.0	+ 8.1	9.8	25.1	+69.1

B. Effect of Heavy Seeding Alone

Table 4 shows the effect of heavy seeding without fertilizer under conditions prevailing at Melfort in 1935, and should be compared with Tables 1 and 8. For instance, whereas in Table 1, fertilizer decreased the percentage weed seeds to total crop in Garnet wheat from 54.1% to 29.7%, heavy seeding alone in Table 4, decreased it from 54.1 to 17.1% and heavy seeding together with the use of fertilizer decreased it from 54.1 to 7%.

TABLE 4.—EFFECT OF HEAVY SEEDING FOR CONDITIONS PREVAILING AT MELFORT IN 1935. CROP NOT FERTILIZED

Crop	Date of seeding	Yield of grain, bus. per acre		Days seeding to maturity		Percentage weed seeds to total crop	
		Light seeding	Heavy seeding	Light seeding	Heavy seeding	Light seeding	Heavy seeding
Garnet	May 13	9.4	16.1	95	93	54.1	17.1
Marquis	May 13	15.5	18.8	103	103	21.9	10.4
Regal	May 14	19.7	36.8	92	88	44.9	6.7
Gopher	May 14	55.5	60.8	92	86	14.3	5.4
Regal	May 30	35.7	48.3	88	81	20.2	5.1
Gopher	May 30	42.5	63.7	84	81	15.3	5.6

Tables 5 and 6 show the effect of heavy seeding without the use of fertilizer on the development of weeds for the tests made in 1932 and in 1933.

TABLE 5.—EFFECT OF DIFFERENT RATES OF SEEDING ON THE YIELD OF WHEAT AND WEED SEEDS FROM THE PLOTS AT WATSON AND LOCKWOOD IN 1932

Location of plot	Date of seeding	Yield of wheat			Percentage weed seeds		
		Rate of seeding wheat bushels per acre			Rate of seeding wheat bushels per acre		
		1	1½	2	1	1½	2
Lockwood	April 15	6.9	10.0	11.0	24.7	7.3	3.8
	May 1	6.1	12.0	11.0	25.1	7.3	7.8
	May 15	9.2	13.0	14.8	10.6	4.9	3.0
	Average	7.4	11.7	12.3	20.1	6.5	4.9
Watson	April 18	20.5	23.2	24.4	14.2	8.1	7.9
	April 28	22.2	20.3	22.9	10.0	10.3	6.6
	May 9	20.8	19.0	24.7	20.7	23.3	11.0
	Average	21.1	20.8	24.0	15.0	13.6	8.5

Table 7 summarizes the yield results with heavy seeding for all tests in northeastern Saskatchewan since 1932. No data are available for 1934 because the plots were destroyed completely by a hailstorm on July 11.

TABLE 6.—EFFECT OF LIGHT AND HEAVY SEEDING ON THE YIELD OF GRAIN AND ON THE DEVELOPMENT OF WEEDS IN THE CROP. ENGLEFELD 1933. PLOTS SOWN WITHOUT FERTILIZER

Crop	Date of seeding	Rate of seeding	Average yield of grain (bus. per acre)	Average no. of mustard pods per plant	Average weight of weed seeds per sq. yd. (gms.)	Reduction in number of weed seeds per square yard
Marquis	April 28	Light	14.0	32.3	13.2	1161
		Heavy	14.4	25.7	10.5	
Reward	April 28	Light	11.0	33.7	10.6	744
		Heavy	14.3	29.7	8.8	
Reward	May 10	Light	12.2	21.5	15.0	2236
		Heavy	14.7	19.5	9.8	
Banner, not packed	June 8	Light	36.4	90.7	6.9	1290
		Heavy	42.7	37.9	3.9	
Banner, packed	June 8	Light	43.3	84.4	9.1	1548
		Heavy	51.6	46.8	5.5	

The years 1936 and 1937 were unusual in northeastern Saskatchewan from the viewpoint of precipitation and temperatures. Rainfall was considerably below normal and hot winds with temperatures nearing 100° F. did considerable harm to wheat and especially to coarse grains. It was

TABLE 7.—AVERAGE YIELD DIFFERENCE BETWEEN PLOTS SOWN LIGHT AND HEAVY, WITHOUT THE USE OF FERTILIZER IN NORTHEASTERN SASKATCHEWAN

Year	Crop	Number of tests averaged	Yield, bus. per acre		Diff., bus. per acre
			Light seeding	Heavy seeding	
1932	Wheat	6	15.2	18.1	2.9
1933	Wheat	8	11.7	13.3	1.6
1935	Wheat	2	12.4	17.4	5.0
1936	Wheat	8	9.8	12.8	3.0
1937	Wheat	25	13.7	14.5	0.8
Average wheat		5 years	12.6	15.2	2.6
1933	Oats	2	39.8	47.1	7.3
1935	Oats	2	49.0	62.2	13.2
1936	Oats	6	32.8	32.8	—
1937	Oats	21	22.7	23.6	0.9
Average oats		4 years	36.1	41.4	5.3
1935	Barley	2	27.7	42.5	14.8
1936	Barley	8	22.1	21.6	−0.5
1937	Barley	24	15.3	17.2	1.9
Average barley		3 years	21.7	27.1	5.4

also dry at Melfort in 1935. There was practically no rain in April, May and July, and the total precipitation for the period from August 1934 to July 1935, was 4 inches below the long-time average. If heavy seeding stood the test during these dry years, there need be little fear of what may happen in years of normal rainfall or in wet years in that area.

The reasons why heavier-than-normal seeding curbs the development of weeds, may be the increase in the quantity of cereal roots in the ground at the critical stage of crop-weed competition, the quicker shading of the spaces between drill rows, and the greater uniformity of stand.

C. Effect of Heavy Seeding with the Use of Fertilizer

It has been stated (4) that when ammonium phosphate is drilled in with the crop, less seed is required than when no fertilizer is used. This may be true on clean land or when weeds are of the kind that can be easily smothered by a good stand of grain. The data presented herein show, on the contrary, that best results with phosphate fertilizer on weedy land are obtained when the rate of seeding is increased. See Tables 8 and 9. Data by Hopkins (12) support these findings.

TABLE 8.—EFFECT OF HEAVY SEEDING WITH THE USE OF FERTILIZER UNDER CONDITIONS PREVAILING AT MELFORT IN 1935

Crop	Date of seeding	Yield, bus. per acre		Days seeding to maturity		Percentage weed seeds to total crop	
		Light seeding, no fert.	Heavy seeding, fert.	Light seeding, no fert.	Heavy seeding, fert.	Light seeding, no fert.	Heavy seeding, fert.
Garnet	May 13	9.4	20.5	95	91	54.1	7.0
Marquis	May 13	15.5	23.8	106	100	21.9	8.8
Regal	May 14	19.7	40.1	92	84	44.9	3.6
Gopher	May 14	55.5	72.6	92	83	14.3	2.9
Regal	May 30	35.7	43.1	88	78	20.2	5.2
Gopher	May 30	42.5	74.0	84	78	15.3	2.8
Average		29.7	45.7	92.8	85.7	28.5	5.0

DISCUSSION

It has been shown that heavy seeding with the use of phosphate fertilizer drilled in with the seed usually results in increased yields of grain. This is quite satisfactory, but more emphasis must be placed on the weed control obtained. Yields of grain are given only to show that the heavier rate of seeding is economical since the extra cost of seed and fertilizer is, in most cases, more than balanced by the extra amount of grain harvested. According to Table 8, heavy seeding with the use of fertilizer decreased the weed seed infestation at Melfort in 1935 from 28.5% to 5%. The weed infestation consisted mostly of wild oats and wild mustard. The amount of wild oat seeds was reduced by 92.9% and that of wild mustards by 57.7%. This represents a reduction of approximately 144 wild oats and 627 mustards or a total of 771 seeds less per square foot. The reason

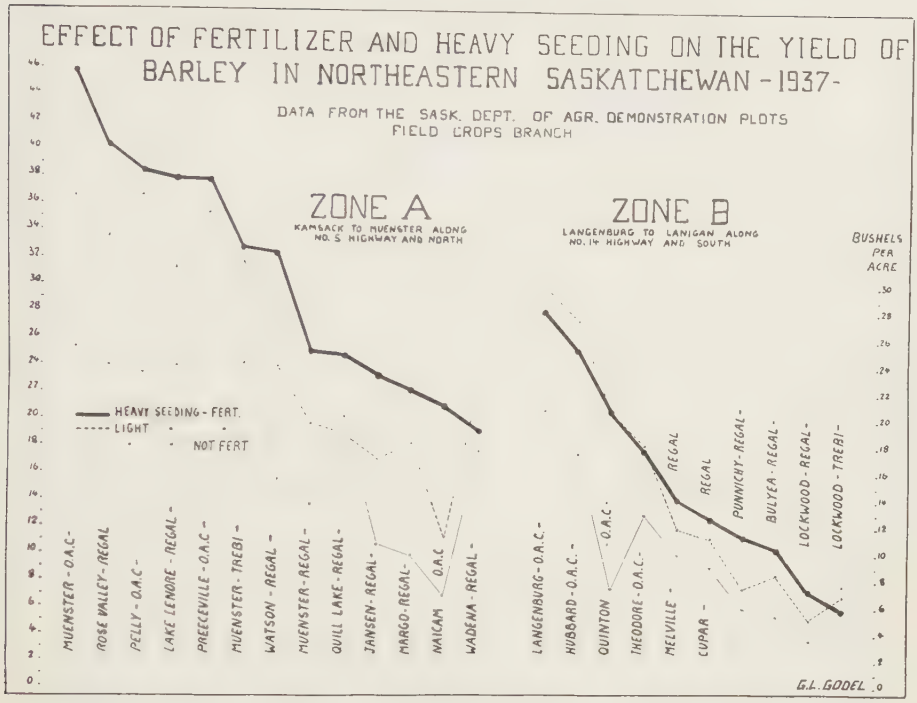

FIGURE 1.

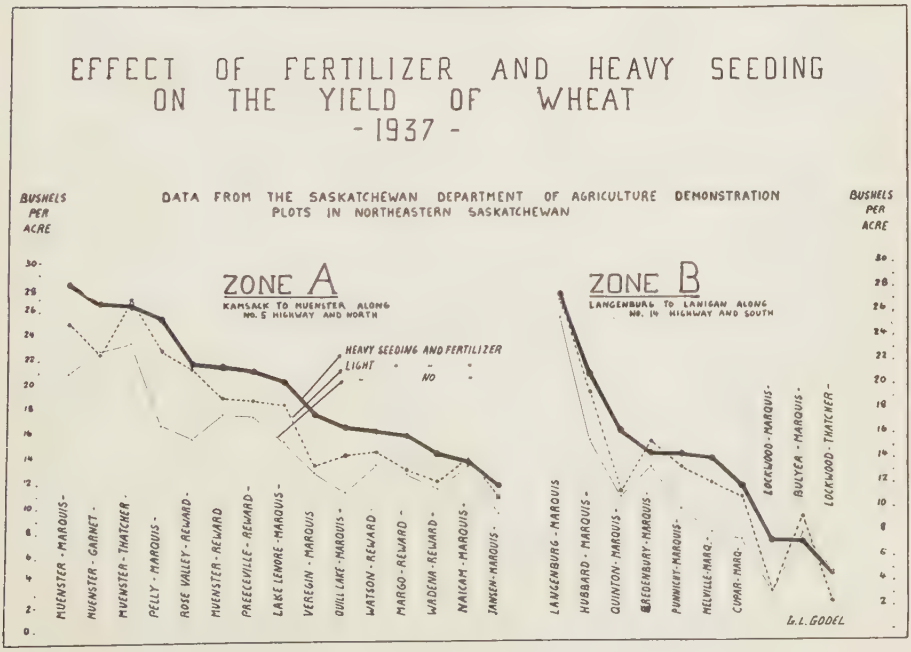

FIGURE 2.

TABLE 9.—YIELDS OF WHEAT, OATS AND BARLEY SOWN LIGHT, WITH AND WITHOUT THE USE OF FERTILIZER, AND SOWN HEAVY WITH THE USE OF FERTILIZER. SUMMARIZED RESULTS*

Year	No. of tests averaged	Light seeding		Heavy seeding fertilized
		No fert.	Fert.	
Wheat—				
1933	4	11.0	14.1	15.5
1935	2	12.4	16.0	22.1
1936	8	9.8	12.0	12.5
1937	25	13.7	15.6	17.5
Average		11.7	14.4	16.9
Barley—				
1935	2	27.7	33.7	41.6
1936	8	22.1	25.2	23.8
1937	23	15.1	21.1	24.0
Average		21.6	26.7	29.8
Oats—				
1935	2	49.0	61.2	73.3
1936	6	32.8	35.3	33.7
1937	20	22.9	28.1	27.8
Average		34.9	41.5	44.9

* The data for oats in 1937 are not reliable because of serious damage at a number of points from army worms. Data for 1934 missing on account of hail.

for more wild oats being smothered than wild mustards can be found in data presented by Pavlychenko on The Relative Development of the Root System of Crop and Weed Plants (18, 19). The vulnerability of wild oats at the early seedling stage is now a proven fact, and complete control of the pest can often be obtained if the grain is sown early and heavy with the use of fertilizer, providing that no severe frost occurs in May. This is especially the case with oats and barley although good results are also obtained with wheat. When the wild oats are not completely smothered, they remain very small deep down between the crop rows and few seeds find their way to the threshing machine.

The results obtained at Melfort in 1935 have often been quoted in this paper not because yield differences were so outstanding, but rather because 1935 was the last year when conditions approaching normal prevailed. Very complete data were also taken on the effect of the treatments on the development of both crops and weeds.

Moisture undoubtedly plays an important part in assuring better results from heavy seeding with the use of fertilizer, but satisfactory results are also obtained under dry conditions, at least with wheat and barley, when fields are weedy. This fact is shown in Figures 1 and 2 which include data from all fields saved from complete ruin by drought in 1937. Note how wheat and barley sown at a heavier rate per acre than is usual in those districts and with the use of from 25 to 30 lbs. per acre of ammonium phosphate (11–48), yielded, in most cases, several bushels per acre more

than crops sown at the normal rates and with fertilizer. Note how in turn the fertilized crop yielded more per acre than the unfertilized crops. The charts underestimate the results that farmers would have obtained in 1937 from the use of fertilizer. In most cases, the unfertilized crops were several inches shorter than the fertilized crops and some of the fields which were sampled by hand for yield data could hardly have been cut with a binder without serious loss. The results for Lockwood were decidedly poor on account of very severe soil drifting, but have been included with the data from the other tests.

Heavy seeding is sometimes criticized because it results in reduced length of culms and heads, decreases stooling and gives smaller kernels. While these results may be obtained on clean land and may lead to yield losses if the year is very dry, these reductions are small where weeds are troublesome because the extra number of plants in the field benefit from moisture, space and soil nutrients which otherwise would have been taken by the weeds. When fertilizer is used as well, further weed control is effected and it often happens that the plants produce heads that are just as long, with longer straw and larger kernels than if the crop had been sown light and without phosphate fertilizer. As far as stooling is concerned, there is almost no stooling on very weedy fields in any case, and in moderately weedy fields, the reduction in stooling is compensated by earlier and more uniform maturity of the crop.

SUMMARY

Perennial weeds, biennials, winter annuals and such annuals as pigweeds, Russian thistle, and wild buckwheat, usually give little trouble, under conditions which assure a normal stand of grain, and where fields are subjected at frequent intervals to good summerfallowing. This is, however, seldom the case with wild mustard, wild oats and stinkweed, and the generally recommended farm practices have failed to bring about a reduction in the infestation of Saskatchewan farms with these weeds. The use of chemical sprays and the practice of delayed seeding to oats or barley for feed, have many objectionable features. The data presented in this paper suggest that seeding grain at a rate heavier than normal, plus the use of phosphate fertilizer drilled in with the seed, provides a practical method of weed control in annual crops. The method is simple, effective and economical as it involves little extra labour, and the cost of extra seed and of fertilizer is generally more than offset by the additional bushels of grain harvested. Heavy seeding with the use of fertilizer results further in materially increased maturity. Heads are usually shorter and the grain stools little, but the loss is more than balanced by the additional number of plants in the field. The method has little effect on the size of the kernels or on the weight per measure bushel. It is at present recommended for weedy fields in the park and wooded soil areas of Saskatchewan. Further experimentation will be necessary to determine the value of this method of weed control in drier areas.

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PRACTICABILITY OF RAPID SOIL TESTS IN TOBACCO PRODUCTION[1]

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INTRODUCTION

For more than a century agricultural chemists have been searching for chemical methods which would have a practical application in diagnosing the needs of the soil. In a sketch dealing with the historical background of chemical tests in relation to plant response, one writer compares this search to the efforts of the early explorers in search for the northwest passage: "At times the search has been hot and at other times cold."

Since the study of the soil testing work at Harrow has been conducted purely along agronomic lines, no specific reference is made concerning the chemical phase of the work except the mention of prominent workers who were responsible for the lead given to chemical soil tests. Russell (6) in an historical sketch cites the many early attempts which were made in search of plant food nutrients. During the middle of the nineteenth century, workers in Germany such as Liebig, Desaussure, and Bousingault indicated the chemical composition of plants. Later in England Lawes and Gilbert established the basic principles of fertilizer practices emphasizing the three essential elements, nitrogen, phosphorus, and potassium, which were important from the standpoint of fertility. Determinations of the total or strong acid-soluble amounts of these elements were especially stressed. Unfortunately much of this work could not be correlated with results obtained in field plot experiments and the interest in soil analyses temporarily declined. In spite of this fact, farmers persisted in sending soil samples to chemical laboratories for analyses, while chemists and agronomists continued to tell farmers that a chemical analysis of the soil was not a reliable basis for fertilizer recommendations. Later, a belief developed that the fraction of plant nutrients which was displaced by treatment with weak reagents was of greater significance to plant growth than the total supply. This trend of thought subsequently led to the development of the present rapid test methods which are designed to show the limits of nutrients which may actually be taken up by the plant. Modern tests are by no means perfected, yet they hold good possibilities for the future. Fundamental differences in the ability of the different crops to take up nutrients of the soil and variations in climate, soil type, rotations, and methods of cultivation necessitate the development of methods of testing and interpretation of results which are suited more or less to a specific set of local conditions. Among the modern workers many names have been mentioned, but those most familiar are Truog (10) of Wisconsin, Morgan (4) of Connecticut, Thomas (8) of Maryland, Thornton (9) of Indiana, Bray (1) of Illinois, Hester (3) of Virginia, and Spurway (7) of Michigan. Among our Canadian workers, Ruhnke (5) of the Ontario Agricultural College at present is calibrating and improvising methods suitable to Ontario crop and soil conditions.

[1] Read before the Horticultural Group of the Canadian Society of Technical Agriculturists at the one-hundred-second meeting of the American Association for the Advancement of Science, Ottawa, Canada, June 29, 1938.

[2] Tobacco Specialist.

SOIL TESTING METHODS AT HARROW

Since rapid soil testing has been approached wholly from a practical aspect, methods and technique have not been emphasized to any great extent at the Harrow Station. At the present time, two soil testing methods are in use on the Station, namely, the Thornton and the Morgan. Both methods have certain limitations as well as possible merits in testing Ontario tobacco soils. The Thornton method was calibrated primarily for soil and crop conditions in the State of Indiana, and it has been found that this method is not too well suited to the range of soils in southwestern Ontario. On the lighter sandy soils the Thornton method does not always give an accurate reading in that it tends to exaggerate the potash levels, while on certain of the heavy soils the phosphate readings were usually found somewhat high. This method, however, serves a useful purpose in checking soils which tend to show especially low mineral levels. Since the Thornton method requires a separate extraction for each nutrient, the demand on time and reagents is a consideration as compared with the Morgan method. In contrast, the Morgan method is fairly well adapted for testing the sandy soils of the tobacco district. Greenhouse soils have also been tested with a fair degree of accuracy by the Morgan method. In testing clay loam soils with this method, the readings for phosphorus and potash usually come below the range provided by the chart. Since levels of the various nitrogen fractions in the soil are apt to fluctuate rapidly over a considerable range as a result of conditions at the time of sampling, more dependence is placed on crop history and general knowledge of the soil than on the nitrogen level indicated by the test.

NUTRIENT LEVELS IN TOBACCO SOILS

In connection with most soil testing services, the question of proper nutrient levels for various crops arises. Fortunately, prior to soil testing at Harrow, numerous fertilizer tests (2) had been conducted on the different tobacc soils of the district, and these served to give a general background as to the requirements of the tobacco crop in respect to the various plant-food elements. These field tests were conducted on a variety of soil types including light sandy loam, dark sandy loam, light gravelly loam, dark gravelly loam, light clay loam, and dark clay loam. This work indicated fairly definitely that specific quantities of nitrogen, phosphoric acid, and potash should be applied in the fertilizer to produce optimum yields of good quality tobacco.

In general it has been found that tobacco in light sandy soils showed greatest response to potash while on heavy soils phosphate applications were of more significance, and intermediate soil types responded about equally to applications of both phosphate and potash. The light sandy soils were generally found to be more acid in reaction than either the intermediate or heavier soil types. While it is possible to determine the relative nutrient levels of these soils prior to the application of the current year's fertilizer, it is not feasible as yet to estimate any definite numerical level. With this information as a background for proper interpretation of rapid soil tests, it has been possible to make recommendations which in 90% of the cases have been highly satisfactory to the grower. The fact

that tobacco growers have become keenly interested in soil testing and also that many have returned to the Station with samples for the third and fourth years is a good indication that this service has a useful place in tobacco production.

DISCUSSION OF RESULTS

Although soil testing has been extended during the past year to treat certain other elements in the soil such as magnesium and calcium, consideration has been given chiefly to the determination of phosphate and potash levels and of pH values. Proper levels of P_2O_5 are found to be exceedingly important in the ripening of the tobacco crop. Potash plays an essential part in quality relations, particularly in curing, while a definite relationship is known to occur between pH levels and the incidence of black root rot in the soil. Most problems in tobacco fertilization occur, therefore, within this scope. Table 1 gives a general picture of soils in Essex County with respect to available phosphate, potash, and pH values.

TABLE 1.

Levels	Phosphorus	Potash	pH
	%	%	
Light Soils (300 samples)			
Low	21	28	26
Medium	38	50	28
High	41	22	46
Heavy Soils (125 samples)			
Low	26	28	0
Medium	55	25	54
High	19	47	46

By arranging these into a more detailed grouping there are indications that the soil type has considerable influence on the phosphorous and potash levels and pH values. Fertilizing and cropping practices also appear to have a similar effect. These comparisons are illustrated by accompanying graphs. Table 2, giving full details, is also attached.

Before examining the graphs, it might be well to mention the fact that the information forming the basis for these comparisons was derived from soil samples which were collected and brought to the Harrow Station by the growers themselves. Although samples were not taken under the supervison of the Station, instructions in sampling were given and those samples which were not taken with reasonable care were not tested. The charts are not strictly comparable because the soils in each group vary in number. The graphs, therefore, represent roughly only an aggregation of the material which was at hand.

Figure 1 includes samples from different old belt tobacco soils. Column No. 1 contains well-drained soils representative of the Oxley district, corresponding with some variation to the Fox fine sandy loams of the new belt. The tests on these soils indicated a medium phosphate level and comparatively low potash level. The majority of these soils were fairly acid.

62758—3½

TABLE 2.—PERCENTAGE OF SOILS OCCURRING AT VARYING LEVELS

Series	Soil type	Designation or treatment	No. of samples tested	Phosphate level						Potash level					
				Very low	low	Medium	Med. high	high	Very high	Very low	low	Medium	Med. high	high	Very high
1	Fox sandy loam	Well drained Oxley soils	54	6	20	31	29	10	4	13	29	22	17	15	4
2	Berrien sandy loam	Poorly drained east of Leamington	23	6	10	44	20	6	14	10	16	35	10	13	16
3	Fox sandy loam	Well drained ridge land soils	42	10	18	30	9	22	11	9	12	25	15	20	19
4	Deep Berrien sand	Comparatively fertile sands, Kingsville district.	43	2	10	50	21	13	4	9	30	20	9	18	14
5	Miscellaneous sandy soils	No fertilizer applied in past four years	14	39	16	45	0	0	0	47	24	29	0	0	0
6	Miscellaneous sandy soils	One year's application of fertilizer	12	17	8	41	26	0	8	0	33	42	0	25	0
7	Miscellaneous sandy soils	Two year's application of fertilizer	11	0	0	44	36	10	10	0	10	44	10	18	18
8	Miscellaneous sandy soils	Three year's application of fertilizer	14	7	7	50	36	0	0	7	28	35	8	14	8
9	Miscellaneous sandy soils	Flue tobacco in continuous	14	7	7	50	36	0	0	7	28	35	8	14	8
10	Miscellaneous sandy soils	Flue tobacco in rotation with tomatoes	13	0	9	36	27	10	18	7	7	22	0	42	22
11	Miscellaneous sandy soils	Flue tobacco in rotation with rye	13	0	0	25	17	50	8	0	9	33	9	9	40
12	Clay loam	General farming	50	8	20	56	16	0	0	20	24	34	6	12	4
13	Gravelly loam	Fertilized in past three years	10	20	10	50	20	0	0	0	20	20	30	30	0
14	Clay loam	Fertilized for tobacco and late tomatoes	35	0	20	50	30	0	0	0	10	10	60	10	10
15	Clay loam	In alfalfa or red clover for two or more years	15	0	28	62	10	0	0	20	20	30	10	20	0

Series	Soil type	Designation or treatment	No. of samples tested	pH level							
				4.0–4.5	4.6–5.0	5.1–5.5	5.6–6.0	6.1–6.5	6.6–7.0	7.1–7.5	7.6–8.0
1	Fox sandy loam	Well drained Oxley soils	54	3	35	32	11	17	2	0	0
2	Berrien sandy loam	Poorly drained east of Leamington	23	0	10	25	20	35	10	0	0
3	Fox sandy loam	Well drained ridge land soils	42	2	14	19	26	28	11	0	0
4	Deep Berrien sand	Comparatively fertile sands, Kingsville district	43	0	10	14	48	18	10	0	0
5	Miscellaneous sandy soils	No fertilizer applied in past four years	14	0	32	15	21	32	0	0	0
6	Miscellaneous sandy soils	One year's application of fertilizer	12	0	16	25	25	34	0	0	0
7	Miscellaneous sandy soils	Two year's application of fertilizer	11	0	45	28	9	18	0	0	0
8	Miscellaneous sandy soils	Three year's application of fertilizer	14	0	43	57	0	0	0	0	0
9	Miscellaneous sandy soils	Flue tobacco in continuous	14	0	43	18	36	10	0	0	0
10	Miscellaneous sandy soils	Flue tobacco in rotation with tomatoes	13	0	36	18	36	10	0	0	0
11	Miscellaneous sandy soils	Flue tobacco in rotation with rye	13	0	10	46	24	20	0	0	0
12	Clay loam	General farming	50	0	0	0	0	40	38	14	8
13	Gravelly loam	Fertilized in past three years	10	0	0	0	10	20	60	10	0
14	Clay loam	Fertilized for tobacco and late tomatoes	35	0	0	0	2	52	36	10	0
15	Clay loam	In alfalfa or red clover for two or more years	15	0	0	0	0	36	54	10	0

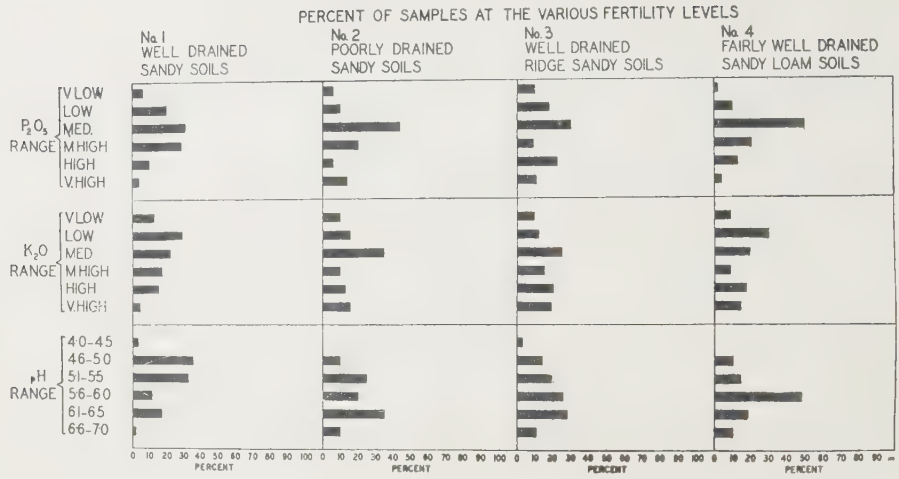

FIGURE 1

Column No. 2 contains poorly-drained sandy loam soils from that part of Mersea township east of Leamington, which correspond somewhat to poorly-drained soils of the Berrien series in the new belt. Tests on the majority of soils in this locality showed slightly lower levels of phosphate and potash, but a relatively high pH.

Column No. 3 contains well-drained soils from the Leamington ridge. These are similar to Column 1 in phosphate but higher in potash and lime. These soils are known to be relatively low in organic matter.

Column No. 4 contains sandy loam soils from the lake region of the township of Gosfield South. For light soils, the farms in this district are fairly productive, and correspond to the better drained deep Berrien sands of the new tobacco belt. The tests indicated these soils to be medium in phosphate and potash, and comparatively well supplied with lime.

Figure 2 includes a summary of observations in relation to fertilizer practices. Where no fertilizer had been used nutrient levels were lower than on farms where fertilizer has been used for one year previous to the

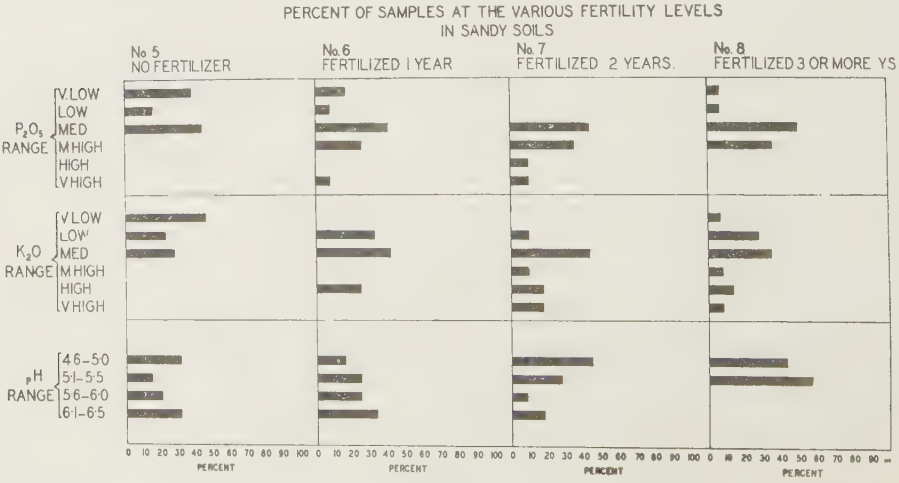

FIGURE 2

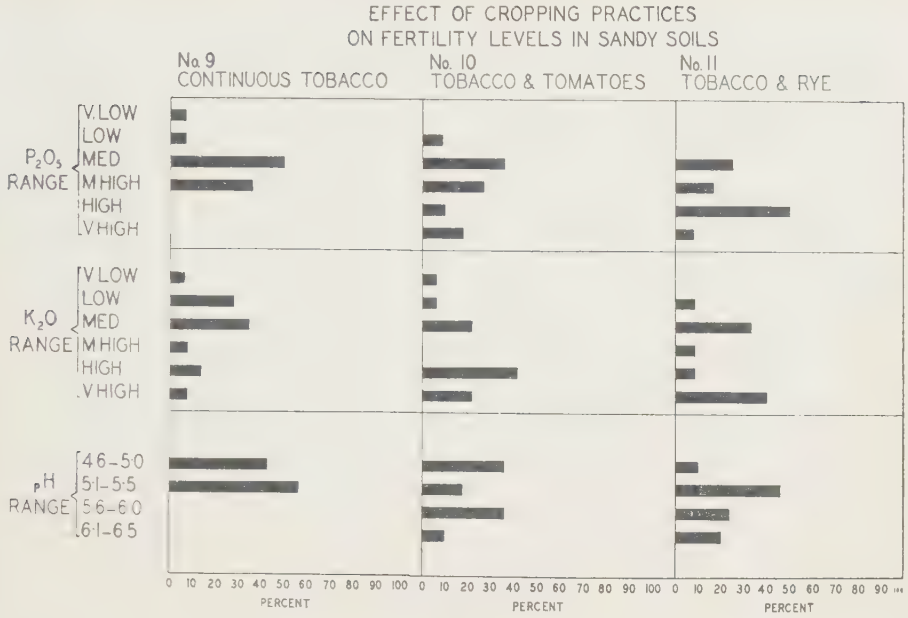

FIGURE 3

test. Where fertilizer has been used for two years mineral levels were still higher, but this trend did not continue on those farms where fertilizer has been used for 3 years previous to the test. In the latter case a more exhaustive cropping system was practised so that factors other than fertilizer applications may be responsible for the range of nutrient levels.

Figure 3 represents a summary of observations in relation to cropping practices. Continuous cropping of tobacco resulted in lower phosphate and potash levels, while a rye and tobacco rotation left higher mineral levels than a tomato and tobacco rotation. Continuous tobacco was associated with a low pH.

Figure 4 gives a summary of observations on heavy soils. Under general farming practices, the rapid tests indicated a doubtful level of

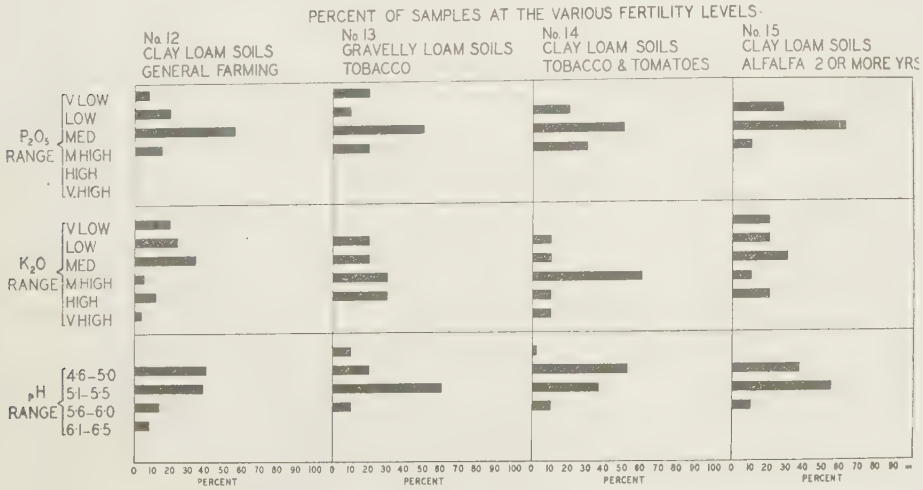

FIGURE 4

available phosphate and potash in the majority of clay loam soils. Tests on gravelly loam soil fertilized during the past 3 years showed that the majority of these soils carried a moderate level of phosphate and a comparatively high level of potash. Fertilized for tobacco and tomatoes, these soils indicated medium to medium high levels of phosphate, and a higher potash level.

Tests on clay loam soils which had produced 2 or more crops of clover and alfalfa showed low phosphate levels. A large percentage of the soils in this group were comparatively low in potash. The lime content of the heavy soils was at a fairly high level throughout, but slightly lower on the average on soils where tobacco and tomatoes had been grown.

The foregoing graphs give a rough picture of the mineral levels and pH values of tobacco soils of the old belt. It must be realized, however, that the actual soil test is only part of the job. Recommendations may be misleading unless those responsible for the work have sufficient information regarding type of soil, method of sampling, drainage, cropping history, condition of previous crops, and fertilizer treatments. A general background of knowledge concerning the farming practice of the district and the response of the crop to particular fertilizers on different soils is required when making individual recommendations. In conclusion, it might be said that with the steadily growing demand for rapid soil testing and with the satisfactory results already obtained with fertilizer recommendations, there is little doubt that soil testing by these methods will reach greater proportions in tobacco production.

SUMMARY

Soil testing at the Harrow Station has been conducted along purely agronomic lines, using the Morgan method for the light sandy soils and the Thornton method for the heavier soils. Testing has been confined chiefly to determining the available phosphate, potash, and pH levels.

Results of fertilizer tests on various soil types have served as a very useful background for the development of soil testing service for the tobacco district. Each soil type has a fairly distinctive level and balance of nutrients and a corresponding response to fertilizer treatments. Cultural and cropping practice may exert a considerable influence on soil fertility. In general, light soils or those continuoously cropped to tobacco tend to be low in potash. Heavy soils are more apt to show a phosphate deficiency. The use of commercial fertilizers tends to raise the mineral levels and acidity. Proper interpretation of rapid soil tests can only be made by virtue of a thorough knowledge of soil type, crop conditions, and fertilizer requirements of the particular soil type in question.

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CROPPING PRACTICES FOR FLUE-CURED TOBACCO IN THE NORFOLK DISTRICT OF ONTARIO[1]

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In the successful production of flue-cured tobacco, the cropping practice followed is second only to the natural character of the soil itself. This phase of tobacco culture is receiving ever-increasing attention in the Norfolk district. Those characteristics, by virtue of which much of the soil in this district is suitable for growing high quality flue-cured tobacco, render it not only responsive to proper treatment but also make it easily destructible by overcropping, excessive tillage, and exposure to rain and wind. Moreover, more than 60% of the land is operated by sharegrowers, most of whom are on short term leases. This factor has not been conducive to the general adoption of far-sighted cropping systems. On some farms where there is not an abundance of suitable land on which to alternate tobacco with another crop it is considered more economical, under present conditions, to take a narrower margin of profit per unit of land than to maintain the productivity of the farm by planting a smaller acreage. Fortunately for the future of the tobacco-growing industry, generally, such cases are very much in the minority. While rye is used extensively as a rest crop and cover crop in the rotation, tobacco often follows one of a number of other crops, such as corn or oats. Methods of handling the rye crop vary greatly from farm to farm and there is little agreement as to how it can be used in the rotation most effectively. The use of barnyard manure for flue-cured tobacco is gaining rapidly in popularity.

It is proposed to discuss in this paper certain phases of the cropping system which are still in a more or less controversial state and to focus attention on particular practices regarding which definite data are available.

EXPERIMENTAL WORK

The effect of different crops and cropping practices in the rotation for flue-cured tobacco is under observation at the Delhi Experimental Substation on plots laid down for this purpose in 1934. The soil which is designated Fox Coarse Sand is described as coarse-textured sandy soil, low in organic matter, and fairly acid in reaction. This soil type is representative of much of the average tobacco land in the Norfolk district. Previous to the initiation of this study the land had lain idle for a period of 20 years and was sparsely covered with Canada blue grass, weeds, and moss. The experimental areas are level in topography and well protected from wind.

The data, to which reference is made herein, were obtained over the 3-year period 1935–37, during which time a wide range of weather conditions was experienced. The growing season of 1935 was considered almost ideal for flue-cured tobacco; 1936 was characterized by an extremely dry growing season accompanied by abnormally high temperatures; while in 1937 there

[1] Read before the Horticultural Group of the Canadian Society of Technical Agriculturists at the one-hundred-second meeting of the American Association for the Advancement of Science, Ottawa, Canada, June 29, 1938.

[2] Officer-in-charge.

was an exceptionally heavy rainfall with floods occurring during the preceding winter and early spring months. All of the tobacco was harvested from the experimental plots in 1935 and 1937. About half of the 1936 crop was frozen and the yield and quality data are based on the portion of the crop which was sufficiently mature to prime before the advent of frost. For this reason the data recorded for 1936 may be considered more as an indication of relative maturity than total leaf produced.

EXPERIMENTAL PROCEDURE

The different treatments were laid out on quadruplicate plots, one thirty-second acre in size, arranged in randomized blocks. Since they were planned for a 2-year rotation, provision was made for sufficient area so that data could be obtained from a tobacco crop in each season. An outline of the treatments compared is summarized briefly in Tables 1 and 2.

Cover crops were sown immediately after harvesting the preceding crops. When barnyard manure was applied the application was made at the rate of 5 tons per acre in the spring before ploughing. The land was ploughed, cultipacked, and prepared for tobacco and the other annual crops during the latter part of April each year. A standard complete fertilizer was applied at the rate of 1000 pounds per acre before planting to tobacco unless otherwise designated. The other crops grown in the rotation to which reference is made in Table 1 received an application equivalent to one-half that applied in each case for tobacco. In 1935 the analysis of the standard fertilizer was 3-10-6, while in 1936 and 1937 a 2-10-8 fertilizer was used.

The tobacco from two rows in the middle of each plot was harvested for yield and quality data. The cured leaf was sorted into commercial grades to obtain a numerical expression of its value.

RESULTS AND DISCUSSION

The fundamental requisites of a cropping system should provide for the maintenance of yield and quality. Among the factors which result in diminished productivity of flue-cured tobacco in the Norfolk district are depleted soil minerals, insufficient supply of suitable organic material, losses from leaching and erosion by wind and water, diseases transmittable through the soil, and a crop-effect disease known as brown root rot. It would be folly to place more importance on one of these factors than another since failure to take any one into consideration may result in reducing the returns to a similar extent.

With our present knowledge and experience it appears impossible to maintain production of flue-cured tobacco when the crop is grown on the same soil two or more years in succession. The data presented in Table 2 tend to confirm this observation. Mosaic is usually prevalent in a tobacco crop planted on land in tobacco the previous year, while the possibility of transmitting this disease from one crop to the next through the soil is practically eliminated if tobacco is alternated with another crop such as rye. In addition, the second and succeeding crops of tobacco evidently suffer from lack of actively decomposing organic material. Barnyard manure may be of value in maintaining productivity in such cases but

TABLE 1.—SUMMARY OF RESULTS OF EXPERIMENTS SEOWING THE EFFECTS OF DIFFERENT CROPS AND CROPPING PRACTICES ON FLUE-CURED TOBACCO IN A TWO-YEAR ROTATION

Rotation			Yield per acre (lb.)				Returns per acre ($)			
1st year	2nd year									
	Crop	Fertilizer	1935	1936	1937	Average	1935	1936	1937	Average
Rye disced when ripe followed by rye cover crop	Tobacco	2–10–8	1363	798	1458	1206	392	180	522	365
Rye harvested, land left without a cover crop	Tobacco	2–10–8	1400	780	1458	1213	411	187	466	355
Sweet corn followed by a rye cover crop	Tobacco	2–10–8	1220	854	1280	1118	368	209	413	330
Sweet corn, land left without a cover crop	Tobacco	2–10–8	1283	830	1280	1131	391	192	428	337
Soybeans ploughed green followed by rye cover crop	Tobacco	*0–10–8	1328	825	1090	1078	413	177	360	316
Soybeans ploughed green followed by rye cover crop	Tobacco	**1–10–8	1333	803	1268	1134	383	162	408	317
Soybeans ploughed green followed by rye cover crop	Tobacco	2–10–8	1365	838	1265	1156	351	169	431	301
Soybeans harvested followed by rye cover crop	Tobacco	*0–10–8	1138	783	910	943	364	181	278	272
Soybeans harvested followed by rye cover crop	Tobacco	**1–10–8	1193	900	1125	1073	357	235	375	316
Soybeans harvested followed by rye cover crop	Tobacco	2–10–8	1280	878	1198	1118	346	209	403	319
Necessary difference for significance according to Snedecor's tables when the average results for the three years are compared (5)				5% point 1% point		62.3 83.0				31.4 41.8
Necessary difference for significance when the average results for each year are compared				5% point 1% point		107.9 143.6				54.2 72.2

* 1935 received 10 pounds nitrogen per acre.
** 1935 received 20 pounds nitrogen per acre.

TABLE 2.—SUMMARY OF RESULTS OF EXPERIMENTS SHOWING THE EFFECTS OF DIFFERENT ROTATIONS, COVER CROPS, AND BARNYARD MANURE ON FLUE-CURED TOBACCO

Rotation	Yield per acre (lb.)				Returns per acre ($)			
	1935	1936	1937	Average	1935	1936	1937	Average
1st year—Rye disced when ripe followed by rye cover crop 2nd year—Tobacco	1388	625	1343	1118	413	124	423	320
1st year—Rye disced when ripe followed by rye cover crop 2nd year—Tobacco, with barnyard manure	1433	503	1385	1107	421	89	459	323
Tobacco every year followed by a rye cover crop	1285	533	1208	1008	414	79	343	279
Tobacco every year with manure, followed by a rye cover crop	1453	363	1280	1032	400	56	374	277
Tobacco every year followed by a cover crop of oats	1253	450	1245	991	347	57	359	254
Tobacco every year, land left without a cover crop	1203	463	1133	933	357	76	345	259
Necessary difference for significance according to Snedecor's tables when the average results for the three years are compared			5% point 1% point	65.7 88.5				29.4 39.6
Necessary difference for significance when the average results for each year are compared			5% point 1% point	138.2 153.3				50.9 68.6

delayed maturity is liable to result from its use, particularly in dry seasons on soils naturally quite productive. At present large quantities of barnyard manure are not produced in the tobacco district, although increasing amounts are procured each year from the general farms in adjacent areas. The value of a rotation of crops for flue-cured tobacco has long been recognized in other tobacco-growing districts of North America. (2).

Soil-building crops such as alfalfa and clovers cannot be used satisfactorily as crops preceding flue-cured tobacco because of their tendency to store up nitrogen in a form which becomes available throughout the following season. On the Substation, following a two-year-old alfalfa sod, tobacco grew very large but matured slowly and was of low quality. When tobacco was planted after either soybeans or corn it suffered from brown root rot and reduced growth resulted. The data in Table 1 indicate that some nitrogen was added by the soybean crop, particularly when it was ploughed under. These data also confirm previous observations that the growth of tobacco increases with the amount of nitrogen available but that the relationship of nitrogen to other nutrients must be carefully controlled to obtain satisfactory maturity and quality.

Among the crops which may be used in rotation with flue-cured tobacco in this district rye seems to have the best combination of desirable features. The rye should be sowed immediately after harvest so that it will produce a cover crop for the winter. If the rye is disced into the soil when ripe the following season a dense volunteer crop follows which protects the land during the winter and early spring. The rye will make considerable growth in the spring before it is necessary to plough in preparation for the tobacco crop. By returning the rye crop to the soil when it is ripe a large amount of organic material of high energy content is added. The young growth, ploughed under in the spring, decomposes readily (3), thus permitting the tobacco to grow rapidly and mature properly.

Although there was little difference in the average results whether the rye crop was returned to the soil or harvested, this is not surprising since the land has not been broken for many years. There is a suggestion that on more productive soils it may be profitable to harvest the rye provided a cover crop is reseeded. Barnyard manure may be used to advantage in this rotation on soils low in organic matter and is particularly beneficial when the rye crop is harvested rather than returned to the land. Under this cropping system the land is occupied by a crop of rye at least 18 months out of every 24. Ploughing is done only once in 2 years. Spring ploughing is superior to fall ploughing on most flue-cured soils and is most effective when the land is packed with a cultipacker immediately after ploughing. Excessive discing and cultivation should be avoided since such operations tend to destroy the physical structure and organic matter in which these soils are naturally poor. Cultivation in excess of that required to loosen the soil which is packed during transplanting and to control weeds appears to be unnecessary and may be harmful.

While erosion by either wind or water may be considered as negligible in the present experiments since the plots are small, level in topography, and well-protected by natural windbreaks, nevertheless these factors must be taken into consideration in adopting a cropping system in the Norfolk district. Both sheet and gully erosion take a real though unmeasurable

toll on many tobacco fields and dust storms are frequently a public menace. Soil erosion control has been a factor in the flue-cured districts of the United States since the early Colonial days (1). Although no definite data are available regarding leaching on these soils it is a significant fact that sand drown, a nutritional disturbance due to a deficiency of magnesium, was first noted in this district during 1937, following a winter and spring with excessive rainfall. The value of a covering such as that furnished by the rye crop has been demonstrated and observed repeatedly (4).

SUMMARY

Reduced yields and returns per acre may be expected when flue-cured tobacco is grown 2 or more years in succession on the same land in the Norfolk district of Ontario.

A rotation in which tobacco is planted every second year with rye on the land throughout the intervening time has given best results. Unless the land is well supplied with organic matter it is well to disc the rye into the soil when ripe. Light applications of barnyard manure may be used to advantage on soils low in natural fertility.

Alfalfa and clovers are not generally satisfactory crops to precede tobacco. Tobacco is liable to suffer from brown root rot following a crop of sweet corn or soybeans.

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SOME EXPERIMENTS DEALING WITH ROPY MILK[1]

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INTRODUCTION

These experiments were conducted: (1) to determine which of the organisms commonly occurring in milk or cream were capable of producing ropiness under controlled conditions; (2) to determine the effect of environment upon a group of bacteria which were considered to be capable of producing ropiness in milk or cream; (3) to see if the fine cohesive curd produced by the *Lactobacilli* would develop the ropy condition; (4) to check the reliability of the "diffusion test" for the presence of ropiness; and (5) to supplement our information gathered through the examination of a large number of specimens during the ropy milk outbreaks which occurred in Ontario last year.

Since the actual source of the organisms causing ropy milk has been a point of controversy for so long, and since the source was determined in 109 cases of ropy milk outbreaks between May 7, 1937 and May 11, 1938, in Ontario, the inclusion of a brief summary of the findings would seem to be justifiable. It is as follows:

Milk submitted by farmers and dairymen	79
Water from cooling vats on farms	9
Farm cisterns	5
Well water	2
Rinse water (3) for milking machines (1)	4
Dairy cans returned to producers	7
Water from drinking troughs	2
Water from stagnant pond	1
	109

Unfortunately, the bacterial types incriminated in these outbreaks could not be identified because of the pressure of other work.

MATERIALS AND METHODS

Cultures

The cultures employed represent different genera, species, and strains, some of which have been reported by other workers as being capable of producing some degree of viscosity in milk. They are listed in Tables 1 and 2. Where several cultures of the same species are indicated they were secured from different sources. The *Lactobacilli* and *Streptococcus lactis* were subcultured every 10 days in sterile milk, the remaining 15 cultures were carried on beef-extract agar slants.

[1] Contribution from the Department of Bacteriology.
[2] Professor of Bacteriology.
[3] Student Specialist in the Department.

Source of Cultures

Lactobacillus acidophilus —Dr. Rosell, St. Hyacinthe, Que.
Lactobacillus bulgaricus —Dr. Rosell, St. Hyacinthe, Que.
Lactobacillus casei —Dr. Rosell, St. Hyacinthe, Que.
Streptococcus lactis —Department "starter"
Alcaligenes viscosus M4 —University of Toronto
Alcaligenes viscosus M4b—Isolated from ropy milk, O.A.C.
Alcaligenes viscosus M4c —Isolated from ropy milk, O.A.C.
Aerobacter aerogenes M3 —Michigan State Coll. (from soil)
Aerobacter aerogenes M3a—Chicago Board of Health
Aerobacter aerogenes M3b—Chicago Board of Health
Aerobacter aerogenes M3c—Chicago Board of Health
Aerobacter aerogenes M3d—Chicago Board of Health
Aerobacter cloacae A2a —Ottawa, X30 (Pensions & Nat. Health)
Aerobacter cloacae A2b —Provincial Dept. Health, Toronto
Escherichia coli M15 —Chicago Board of Health
Escherichia coli M15a —University of Toronto
Proteus vulgaris A28 —Prov. Dept. Health, Toronto, (X19 No. 11)
Proteus vulgaris A28a —University of Toronto
Bacillus panis viscosus —Isolated from bread, O.A.C.) (A. Davey)

Milk and Cream

Milk and cream were obtained fresh from the Dairy Department of the College, as needed, and were collected in sterile flasks.

Environmental Conditions

The two chief factors of consideration were the medium, and the temperature of incubation. Each organism was tested in raw milk, pasteurized milk and sterilized milk, and the cultures were incubated at temperatures of 18° C., 25° C., and 30° C. This was repeated using cream as the medium, which was prepared in the same manner. All tests were conducted in triplicate. Brom-cresol-purple indicator was added to the third series before dispensing the milk and cream in the test tubes, in order to get some idea of the change in the pH of the medium brought about by the action of the bacteria or the processing, or the residual flora surviving pasteurization or sterilization.

In addition to the above, one series of six organisms—*Lactobacillus acidophilus, L. bulgaricus, Streptococcus lactis* and three strains of *Alcaligenes viscosus*, was tested in raw, pasteurized and sterile milk and incubated at 4° C., but since no ropiness developed after ten days, this temperature was omitted from subsequent tests. Controls of raw, pasteurized and sterilized milk and cream were included in all tests at the various incubation temperatures. These were not inoculated.

Procedure

All test-tubes were plugged with cotton and sterilized in a gas oven at 180° C. for one hour before use. The milk and cream were thoroughly mixed prior to tubing and divided into three lots. One group was left untreated, one pasteurized at 145° F. (62.5° C.), and one lot sterilized in the autoclave for 15 minutes at 15 pounds pressure. Inoculations were

made by means of a platinum loop, and the inoculated tubes were incubated along with the controls at the appropriate temperatures. Tests for ropiness were made daily for 7 consecutive days with a platinum loop.

The results of the tests conducted in triplicate were in agreement with one another and are recorded in Tables 1 and 2.

The Diffusion Test for Ropiness

This test is employed quite extensively by dairymen and is favoured because of its simplicity. It merely involves the adding of the milk to be tested, drop by drop, to a beaker of water. If the milk diffuses into the water it is considered to be free from ropiness, whereas a drop of ropy milk will remain in the water as a more or less viscous mass with only partial diffusion.

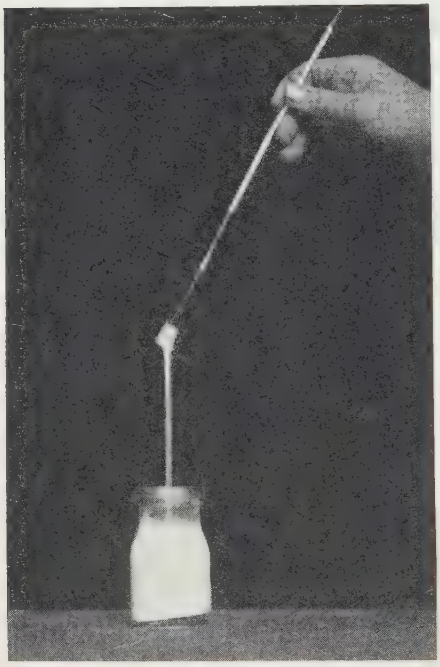

FIGURE 1. Ropy milk produced from sterilized milk inoculated with *Alcaligenes viscosus*, after twenty-four hours' incubation.

Twelve flasks, each containing approximately 150 ml. of raw whole milk, were sterilized by autoclaving at 15 pounds for 20 minutes. Three flasks were inoculated with *Alcaligenes viscosus*, three with *Aerobacter cloacae*, and three with *Lactobacillus casei*, leaving three flasks uninoculated, as controls. One flask of each set was incubated at 18°, 25° and 30° C. respectively, with one control for each. Daily tests were made for ropiness with a platinum loop. After 5 days' incubation, maximum ropiness had developed with *Alc. viscosus* at 25° C., and the milk could be strung out over a foot in length. The diffusion test with controlled modifications was conducted on all samples at this time. The milk samples were tested after being adjusted to 4°, 18°, 25° and 30° C., as this range would probably include the extremes prevailing in ordinary practice. The temperature of the water into which the milk was "dropped" was adjusted to 4° C. (cold), 37° C. (warm) and 65° C. (hot). The results are recorded in Table 3.

RESULTS AND DISCUSSION

On examination of the results presented in Table 1, which deal with tests on raw milk, the most striking feature observed is that samples of raw milk inoculated with the 19 cultures and incubated at the 3 different temperatures failed to show any sign of ropiness or even a trace of viscosity. It will also be observed that these samples gave an acid reaction with Brom-cresol-purple. The failure on the part of the three cultures of *Alc. viscosus* and *Aerobacter cloacae* to produce ropiness in these instances is attributed

TABLE 1.—RESULTS OF TESTS TO DETERMINE THE ABILITY OF BACTERIA TO PRODUCE ROPINESS IN MILK UNDER CONTROLLED CONDITIONS

Organisms	Incubated at 18° C.			Incubated at 25° C.			Incubated at 30° C.		
	Raw milk	Past. milk	Sterile milk	Raw milk	Past. milk	Sterile milk	Raw milk	Past. milk	Sterile milk
L. acidophilus	−a	−n	−a	−a	−c	−a	−a	−a	−a
L. bulgaricus	−a	−n	−a	−a	−c	−a	−a	−a	−a
L. casei	−a	−n	−a	−a	?(3)c	?(3)a	−a	−a	−a
Strep. lactis	−a	−n	−a	−a	−c	−a	−a	−a	−a
Alc. viscosus (M4)	−a	+(2)b	+(1)b	−a	+(2)b	+(2)b	−a	+(2) ×b	+(2)□b
Alc. viscosus (M4b)	−a	+(2)b	+(1)b	−a	+(1)b	+(1)b	−a	+(2) ×b	+(1) ×b
Alc. viscosus (M4c)	−a	+(2)b	+(1)b	−a	+(1)○b	+(1)b	−a	+(2) ×b	+(1)□b
Aer. aerogenes (M3)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3a)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3b)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3c)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3d)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Aer. cloacae (A2a)	−a	−b	−b	−a	−b	−n	−a	−b	−n
Aer. cloacae (A2b)	−a	−b	?(6)b	−a	+(5)b	+(5)n	−a	−b	+(4) ×n
Esch. coli (M15)	−a	−a	−a	−a	−n	−a	−a	−a	−a
Esch. coli (M15a)	−a	−a	−a	−a	−n	−a	−a	−a	−a
P. vulgaris (A28)	−a	−b	−b	−a	−b	−b	−a	−b	−b
P. vulgaris (A28a)	−a	−b	−b	−a	−b	−b	−a	−b	−b
P. panis	−a	−b	−b	−a	−b	−b	−a	−b	−b
Controls	−a	−b	−b	−a	−b	−b	−a	−b	−b

− = no ropiness.
\+ = ropiness: the number following indicates days of incubation before ropiness developed.
? = doubtful—a slimy rather than ropy condition.
Where not otherwise indicated ropiness continued throughout the 7 days of the test.
× = ropiness disappeared after 2 days.
□ = ropiness disappeared after 3 days.
○ = ropiness disappeared after 4 days
a = acid
b = alkaline } to B.C.P. indicator.
n = neutral

TABLE 2.—RESULTS OF TESTS TO DETERMINE THE ABILITY OF BACTERIA TO PRODUCE ROPINESS IN CREAM UNDER CONTROLLED CONDITIONS

Orgarisms	Incubated at 18° C.			Incubated at 25° C.			Incubated at 30° C.		
	Raw cream	Past. cream	Sterile cream	Raw cream	Past. cream	Sterile cream	Raw cream	Past. cream	Sterile cream
L. acidophilus	−a	−n	−a	−a	−a	−a	−a	−a	−a
L bulgaricus	−a	−n	−a	−a	−a	−a	−a	−a	−a
L. casei	−a	−n	−a	−a	−a	−a	−a	−a	−a
Strep. lactis	−a	−n	−a	−a	−a	−a	−a	−a	−a
Alc. viscocus (M4)	−a	−b	−n	−a	−b	−b	−a	−b	−b
Alc. viscosus (M4b)	−a	+(3)b	+(5)n	−a	+(1)b	+(2)n	−a	+(1)b	+(1)b
Alc. viscosus (M4c)	−a	+(5)n	+(6)n	−a	+(1)b	+(2)b	−a	+(1)b	+(2)b
Aer. aerogenes (M3)	−a	−a	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3a)	−a	−a	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3b)	−a	−a	−a	−a	−a	−a	−a	−a	−a
Aer. aerogenes (M3c)	−a	−a	−a	−a	−a	−a	−a	−a	−a
Aer. Aerogenes (M3d)	−a	−a	−a	−a	−a	−a	−a	−a	−a
Aer. Cloacae (A2a)	−a	−n	−n	−a	−n	−n	−a	−b	−b
Aer. cloacae (A2b)	−a	−n	−n	−a	−n	−n	−a	−b	−n
Esch. coli (M15)	−a	−n	−a	−a	−a	−a	−a	−a	−a
Esch. coli (M15a)	−a	−a	−a	−a	−a	−a	−a	−a	−a
P. vulgaris (A28)	−a	−b	−b	−a	−b	−b	−a	−b	−b
P. vulgaris (A28a)	−a	−b	−b	−a	−b	−b	−a	−b	−b
P, panis	−a	−b	−b	−a	−b	−b	−a	−b	−b
Controls	−a	−b	−b	−a	−b	−b	−a	−b	−b

− = no reaction.
\+ = ropiness: The number following indicates period of incubation, in days, before ropiness developed.
a = acid
b = alkaline } B.C.P. indicator.
n = neutral

TABLE 3.—RESULTS OF TESTS TO DETERMINE EFFECT OF VARYING TEMPERATURES OF MILK AND WATER ON THE RELIABILITY OF DIFFUSION METHOD OF TESTING FOR ROPY MILK

Ropy milk at varying degrees of ropiness	Water at 4° C. Milk temperatures				Water at 37° C. Milk temperatures				Water at 65° C. Milk temperatures			
	4° C.	18° C.	25° C.	30° C.	4° C.	18° C.	25° C.	30° C.	4° C.	18° C.	25° C.	30° C.
Alc. viscosus M3 Very ropy by loop test	+	+	+	+	+	+	+	+	–	–	–	–
Alc. viscosus M3 Slightly ropy by loop test	–	–	–	–	–	–	–	–	–	–	–	–
Aer. cloaceae A2b Slightly ropy by loop test	–	–	–	–	–	–	–	–	–	–	–	–
L. casei Slimy (or sl. ro.) by loop test	–	–	–	–	–	–	–	–	–	–	–	–
Controls	–	–	–	–	–	–	–	–	–	–	–	–

+ = no diffusion, indicates ropy milk.
– = instant diffusion, indicates no ropiness?

to the rapid production of acid by the normal acid producing microflora of the milk (chiefly *Strep. lactis*).

It will be observed that one strain of *Aero. cloacae* produced ropiness in the pasteurized and sterilized milk when incubated at the higher temperatures (25° and 30° C.) but only after a long incubation period of 4 to 5 days, whereas *Alc. viscosus* produced ropiness in 1 to 2 days at these temperatures as well as at the lower temperature of 18° C.

Lactobacillus casei produced that characteristic viscous condition in the processed milk, incubated at 25° C., which is associated with an extremely smooth curd.

In all other tests, regardless of the acidity or alkalinity of the medium, no ropiness was detectable.

When cream was used as the test medium, ropiness was much more restricted, as will be seen from the results presented in Table 2. At the lower temperature the time required to produce ropiness was from 3 to 6 days. One strain of *Alc. viscosus* which was active in milk, failed to produce any noticeable increase in viscosity in cream, in spite of the fact that the processed cream gave a neutral or alkaline reaction to the B.C.P. indicator. It is evident that some factor other than pH reaction plays an important role in the production of increased viscosity; it seems highly probable that available oxygen supply for the organisms might be a limiting factor.

It is of interest to note that at the higher temperature, 30° C., the ropy condition does not last as long as it does at the lower temperatures of 18° and 25° C. We have noticed on several occasions that samples submitted for examination, and which were ropy when shipped, failed to show any sign of ropiness when received at the laboratory.

The results of the tests conducted to determine the reliability of the diffusion test in detecting the presence of ropiness, show quite clearly that when the temperature of the water is 37° C. or lower, the test is satisfactory even when the temperature of the ropy milk varies between 4° and 30° C. When the temperature of the water was increased to 60° C., however, the test was not reliable. It would appear that the test is not a very sensitive one since it failed to detect any samples except those that showed pronounced ropiness when touched with a platinum loop. Ropiness of a less marked degree was not detectable by this test.

SUMMARY

1. Three strains of *Alcaligenes viscosus* produced pronounced ropiness in milk when incubated at 18°, 25° and 30° C. They failed to produce ropiness in raw milk which became acid through the development of the lactic-acid producing bacteria present.

2. *Lactobacillus casei* produced a slightly slimy condition in pasteurized and sterilized milk at 25° C. which might be confused with ropiness.

3. One strain of *Aerobacter cloacea* produced typical ropiness in pasteurized and sterilized milk at 25° C., in sterilized milk at 30° C., and somewhat doubtful ropiness in sterilized milk at 18° C.

4. Cream did not prove to be as satisfactory a medium for the development of ropiness as did milk. One strain of *Alc. viscosus* which produced marked ropiness in milk, failed to do so in cream.

5. Pasteurization and sterilization of milk and cream favour the development of ropiness by reducing the competition of the acid-forming bacteria. The production of acid in milk generally prevents the development of ropiness.

6. The diffusion test for the detection of ropiness in milk was not affected by variations in temperature of the water between 4° C. and 37° C., nor by variations in the temperature of the ropy milk between 4° C. and 30° C. When the temperature of the water was increased to 65° C. the test was unsatisfactory. The lack of sensitiveness limits the value of this test.

BOOK REVIEW

GOULDEN, C. H. Methods of Statistical Analysis. Second edition (revised), 209 pp. mimeo. Burgess Publishing Co., Minneapolis, Minn., U.S.A. 1937.

The early appearance of a second edition of this work is indicative both of the increasing extent to which research workers in biology and agriculture are finding it necessary to familiarize themselves with the methods of mathematical statistics, and of the degree to which the first edition was found to be of service in this connection.

Dr. Goulden presents his subject in 15 chapters. These cover most of the topics usually included in statistical courses for biologists, although some analysts of bacteriological, entomological and botanical data may regret the absence of any reference to the Poisson distribution, and of a more than incidental treatment of the Binomial. After a short initial discussion of the functions of statistical analysis the reader is introduced, *via* frequency tables and their preparation, to the "normal" frequency distribution and probability calculations from the normal curve, and thence to tests of significance with small samples. The correlation coefficient, linear regression, partial and multiple correlation, the X^2 test for goodness of fit and independence or association, and tests of goodness of fit and independence with small samples are then discussed and illustrated in turn. The nine chapters dealing with the foregoing topics occupy, however, only slightly more than one-third of the book, the remaining two-thirds being devoted to the analysis of variance and covariance, and different applications of these. Chapter XI, on the field plot test, is easily the longest in the book (55 pages). It traverses the whole range of modern arrangements associated with the names of Fisher and Yates, beginning with the layout and analysis of ordinary randomized block and Latin square types, passing on to a consideration of factorial experiments and the variations in the design of these made possible by split-plot arrangements and the introduction of the device of confounding, and concluding with descriptions and fully worked examples of the incomplete block designs, both pseudo-factorial and symmetrical, recently developed for increasing the accuracy of tests of large numbers of varieties. In this connection, it might perhaps have been desirable to emphasize the fact that, although the principles of design described were evolved in response to the specific problems presented by field trials, their applicability is by no means confined to agronomic experimentation.

In his preface, the author explains that since this book is designed primarily for "those who are accustomed to thinking in terms of practical units of measurement rather than in algebraic formulae", the development of statistical ideas in it is based on the working of actual examples, or on their presentation "in terms of concrete values". This principle has been consistently adhered to, and the thoughtful reader must appreciate the trouble which Dr. Goulden has taken in collecting from diversified sources the many series of actual data which provide material for examples and exercises.

Such a method of instruction has much to commend it, and no one will dispute the necessity for the working through of actual numerical

examples if a proper grasp of statistical methods is to be attained. Yet the very success of such a procedure carries with it certain dangers, and it might be well to sound an occasional note of warning against the sometimes insidious delusion that facility in the practical application of methods and formulae renders unnecessary further efforts to secure the best possible theoretical grounding. All statistical methods are developed from certain initial assumptions, and hence have their limitations. Consequently, whilst it is obviously necessary to know *how* to use a given method, it is equally, though perhaps less obviously, necessary to know *when* to use it and when not. This is well exemplified in Chapter IX, dealing with tests of goodness of fit and independence with small samples. It should not be forgotten, however, that the analysis of variance procedure, with which this book is so largely concerned, is itself deduced from certain assumptions, namely the normal and independent variation of the residuals, and the homogeneity of intra-class variances, which are not always realized in practice. Sampling experiments by E. S. Pearson and by Eden and Yates indicate that tests of significance based on the "*t*" and "*z*" distributions are not seriously affected by moderate departures from normality, so that the range of data to which the procedures outlined may be legitimately applied is undoubtedly very wide. Nevertheless, several recent papers by both Bartlett and Cochran have directed attention to the fact that heterogeneity of variance not only may but does occur in certain types of data, to an extent invalidating the usual tests of significance. A short critical appraisal of the factors limiting the applicability of the various methods described might therefore further enhance the usefulness of future editions of this work to both students and teachers.

The typescript reproduction in the copy reviewed is clear and legible, but it cannot be said that typographical errors are entirely absent.

J. W. Hopkins.